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BULLETIN

OF THE

GEOLOGICAL, MINING, AND METALLURGICAL SOCIETY OF INDIA

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EDITOR : MR. S. RAY

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BULLETIN
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SOCIETY OF INDIA

No. 9 | APRIL, 1951

Society's Comments on "The Mineral Concession Rules 1949"

The Government of India, Ministry of Works, Mines and Power during the year 1949 finally adopted the "The Mineral Concession Rules, 1949" which came into force from the 25th October, 1949.

The Society after careful consideration of the above rules find that the Mineral Concession Rules as passed by the Government do not seem to be free from certain inperfections and defects which might lead to confusion and practical difficulties causing thereby sufficient hardship on the lessees. In some places the statements are vague and inappropriate and there appear also certain self contradictory remarks. There is thus enough room for improvement of these rules. It is therefore highly desirable that suitable amendments be adopted by the Government to make the rules perfect and free from any flaw. The Council therefore proposes to put forward its suggestions on the topic and hopes that the Central Government will give due consideration to them and take suitable measures to amend these rules at the earliest opportunity for the proper development of the mineral resources of the country. Moreover the rules as adopted have given undue privilege and power to the Provincial Governments who may act in their own ways thereby causing undue hardships to the lessess in the different adjoining provinces in the matter of mineral development. The Central Government should modify the rules in such a way that these rules might be applicable to all the deposits in uniform manner throughout the different parts of this country.

The Society has all along been suggesting to the India Government that there should be uniformity in the rules and regulations regarding exploration, prospecting and extraction of mineral deposits in the different parts of the Indian Union and for this purpose India should be considered as a single unit devoid of provincial barriers because Geology knows no political boundary. Such steps if taken will certainly create a healthy atmosphere in the prospecting and mining world. The India Government should not allow the Provinces to have too much autonomy in the matter of mineral development except in the matter of execution of rules and regulations framed by the Central Government. The Society also suggested on many occasions that the subject of mineral development should rest exclusively with a portfolio of the Central Government and not with the Provincial Governments.

There have been frequent complaints from many quarters regarding the delay in the issue of Certificate of Approval and Mining leases by the Provincial Governments.

The Society views with great concern that such delays in the Provincial Government administration would cause a serious check on the progress and development of the Mineral Industry of India. This delay in the Provincial Government administration might possibly be due to want of sufficient technical knowledge in the personnel.

It is therefore suggested that the Provincial Governments should appoint technically qualified officers in different mining districts to deal with such matters failing which the administration of the Mines and Minerals (Regulation and Development) Act, 1948 and the Mineral Concession Rules, 1949 be vested with the Indian Bureau of Mines for obtaining greater efficiency in the matter.

The Society begs to submit in the following lines several comments on "The Mineral Concession Rules, 1949" for favour of careful consideration by the Central Government.

CHAPTER I.

GENERAL.

Rule 3 (iii)

The list of minerals given does not seem to be exhaustive and may give rise to disputes. The rule should be worded as follows :

"A mineral will be considered 'minor' when it does not require heavy capital expenditure and elaborate mining methods and will include building stone, slate, boulder, gravel, sandstone, limestone and kankar used for lime burning, morrum, brick earth, ordinary clay, road metal, placer gold, ochre, kaolin, etc."

Should the exploitation of any of the minor minerals be done on a massive scale so that the producer would require the protection which a long lease affords in working it, the mineral should at once be upgraded to the major mineral group and the terms of concession ratified accordingly.

Rule 4.

After "Minerals" add

"Local Government must frame rules to regulate the concession for minor minerals".

CHAPTER II.

CERTIFICATE OF APPROVAL.

The system of "Certificate of Approval" is neither necessary nor desirable in free India. Mineral discoveries leading to establishment of great industries in Australia, Canada, U.S.A. and in fact all over the world have nearly always been done by fortune-seeking enterprising explorers and not necessarily by geologists or great financiers. In order therefore to provide incentive to all citizens of India to search for minerals, the Society considers that the Certificate of Approval should be abolished and be replaced by "Miner's Rights" as in Australia, a Miner's Rights providing the holder with an authority to search for mineral deposits over a country and a right for mineral concessions. In Canada a Prospecting license, Miner's license, Miner's certificate (equivalent terms used in different parts of Canada) can be obtained by any person paying a fee of $ 5-10 and this confers the same rights to the holder as above.

A person desiring to search for mineral must first provide himself with a Miner's Rights obtainable from the local Government.

Note : In subsequent rules wherever the word "Certificate of Approval" appears it should be substituted by the phrase "Miner's Rights".

CHAPTER II.

MINER'S RIGHTS.

Rule 5.—A "Miner's Rights" shall only be granted by a Provincial Government.

Rule 6.—Any citizen of the Indian Union shall be entitled to get a "Miner's rights" on payment of the prescribed fee, provided, that in the case of a company or a firm, it must be incorporated or registered in India.

Rule 7.—An application for a "Miner's Rights" shall be submitted to the Provincial Government and shall contain the following particulars :—

(*i*) If the applicant is an individual, his name, nationality, profession and residence.

(*ii*) If the applicant is a company, syndicate, partnership of private firm, its name, nature, and place of business, place of incorporation or registration.

Rule 8.—A "Miner's Right" shall be valid for the whole of the province and shall cover all minerals except coal and natural petroleum and natural gas.

Rule 9.—(*i*) A "Miner's Rights" shall have effect from the date on which it is granted and shall expire at midnight on the 31st December next following provided that a "Miner's Rights" granted in the last quarter of the year shall be valid until 31st December of the year next following.

(*ii*) Only one person shall be named in a "Miner's Rights" and the fee payable for the grant thereof shall be Rs. 100.

Rule 10.—A "Miner's Rights" shall be renewable on payment of a renewal fee of Rs. 10 only if the application for renewal is received within 3 months of its date of expiry. After the expiry of three months, the full fee of Rs. 100 shall have to be paid for a fresh issue of Miner's Rights.

Rule 11.—The name and address of the person to whom a "Miner's Rights" is granted shall be published by the Provincial Government in the official Gazette.

Rule 12.—The expiry of "Miner's Rights" shall not affect the validity of any license or lease granted to the holder during the currency of his "Miner's Rights", but after its expiry if he wishes to apply for any license or lease over fresh areas, he shall have to get a fresh "Miner's Rights".

CHAPTER III.

Ruls 13—Replace "Certificate of Approval" by "Miner's Rights"

Rule 14 (*b*)—Read "Miner's Rights" for Certificate of Approval".

Rule 17 (2)—Replace by the following changes, :—

"In case of refusal intimation of the same shall be given to the applicant in writing with the reasons for the refusal and the fee paid under Rule 15 shall be refunded The applicant shall have the right to appeal to the Centre against the refusal"

Rule 18.—In such cases the first applicant is in nearly all cases the discoverer of the deposit. His prior right should not be whittled down but should rather be strengthened. Rule 18 should read thus :—

In the case of more than one application being received covering the same land, the prior right to a license shall, subject to any order to the contrary which the Central Government on a reference made to it may for definite and strong reasons pass in any particular case, be deemed to lie with the applicant, who, being the holder of a valid Miner's Rights and after due compliance with the procedure prescribed by the rules, be the first to file his application.

Rule 20 (4)—Replace " Certificate of approval " by " Miner's Rights ".

Rule 20 (9)—Add " Or its refusal with reasons for the refusal ".

Rule 21—Replace by the following :—

The register shall be open to inspection by any holder of a valid Miner's Rights or his duly authorised agent, on payment of a fee of Re. 1/- per hour leviable uniformly in all the provinces.

Rule 22 (2)—Read "further extended automatically" in place of "further extended."

Rule 23 (1)—Add "but no fee shall be charged for the extension granted of the term of the license under Rule 22 (2)".

Add further,

"Provided that the minimum rate of two annas per acre will normally be applicable for all land except when there is a keen competition for concessions and the land is known to be rich in minerals or when the area applied for appears to be unreasonably large. In the latter cases a higher fee may be reasonably levied varying with the value of the right. "

Rule 23 (i) (ii)—Replace by " The licensee shall have the right to win and carrry away any quantity of any mineral for commercial purposes, as soon as he applies for a Mining lease on payment of the prescribed fees and provided that he conforms to the rules of Mining lease and wins minerals only from the area over which he has asked for lease."

Rule 23 (i) (vi)—It should be as follows :—

"In case of breach by the licensee or his transferee or assignee of any of the conditions of his license, the Provincial Government shall give notice in writing to the lessee asking him to remedy the breach within thirty days from the date of notice, and if the breach is not remedied within such period, the Provincial Government may cancel the license, or forfeit in whole or part of the deposit made under Rule 19."

Rule 23 (2)—Add Rule 23 (2) (x) as follows—

"In case of any dispute between the licensee and the Provincial Government the licensee shall have a right to appeal to the Central Government."

CHAPTER IV

Rule 26 - Replace "holding a certificate of approval" by "holding a Miner's Rights or a prospecting license."

Rule 28—Add " In case of refusal by the Provincial Government the applicant shall have a right to appeal to the Central Government."

Rule 32—In case of more than one application being received covering the same land, the prior right to a lease shall, subject to any Order to the contrary which the Central Government on a reference made to it may for definite and strong reasons pass in any particular case, be deemed to lie with the applicant, who, being the holder of a valid Miner's Rights and after due compliance with the procedure prescribed by the rules, shall have been the first to file his application.

Rule 34—Replace it by the following :—" The register shall be open to inspection by any holder of a valid Miner's Rights or his duly authorised agent on payment of a fee Re. 1/- per hour leviable uniformly in all the Provinces."

Rule 38. In case of mica it may be said that as it occurs in pegmatites having dips varying between wide limits strict enforcement of this rule in certain cases may not be found suitable for any well organised undertaking. It is thus necessary that this rule should not strictly apply in case of mica properties.

Suggested amendment :

Rule No. 38. Add " In case of mica length and breadth should be equal".

Rule 35—Replace the first two paragraphs by " A mining lease may be granted for such area as the applicant may desire and over which the local Government has no reasonable objection."

Rule 38, Rule 40 (1)—Replace it by the following ; " The period for which a mining lease may be granted shall not exceed 30 years in the case of iron-ore, bauxite for manufacture of aluminium, limestone for cement and dolomite for manufacture of magnesium and 20 years in the case of any other mineral.

Provided that the lease shall be renewable at the option of the lessee, for one or two periods, each not exceeding the duration of the original lease for all minerals."

Rule 41 (1) (i)—For " Leased areas" substitute " railhead or port."

Rule 41 (1) (ii)—Add " or at least applying for such lease" after " without obtaining a lease therefore."

Rule 41 (1) (iv)—Add " Provided that the rate of surface rent charged is not greater than the rate of rent current in the neighbourhood and for waste and forest lands the rate should usually be four annas per acre and never more than a rupee per acre.

Add Rule 41 (2) (xv) as follows :—" Right of the lessee to appeal to the Central Government in case of any dispute."

Add Rule 55 as follows :—"Applications for prospecting license or a mining lease shall not be accepted in respect of an area over which a prospecting license or a mining lease was once issued and was subsequently surrendered, cancelled, or determined until and unless the Provincial Government has publicly notified that such pre-existing license or lease has expired, or has been surrendered or cancelled and the area is available for regrant."

Add Rule 56 as follows :—" In case of all dispute between applicants for mineral concessions and the Provincial Government, the applicant shall have a right to appeal to the Central Government."

Add Rule 57 as follows :—" Standard forms shall be used all over the Indian

Union for prospecting licenses and mining leases, the forms being appended with the rules."

SCHEDULE I

Royalty.

The royalty rates that have been adopted with regard to mica are considered to be very high. Besides, there are other expenses to be incurred in transporting the mica books from the mines to the factories. Moreover the recovery of trimmed mica from the crude mica averages from 15-20% only. The rates already appear rather too high for Indian mica to compete with Brazilian mica. On account of this serious competition the India Government had to take suitable measures to ban the import of Brazilian mica to safeguard the interest of Indian mica industry.

It is therefore highly desirable that these high rates should be modified and that the following rates as suggested by the Society may be substituted in place of those already adopted:—

2. Mica.	
(*a*) Crude mica	Four annas per md.
(*b*) Trimmed, mica clear	Rupee one per md.
(*c*) Trimmed mica, spotted.	Eight annas per md.
(*d*) Waste and scrap mica.	One anna per md.
5. Manganese ore.	5% of sale value at pit's mouth.
6. Chromite.	do
7. Limestone or dolomite.	do
8. All other minerals.	do

Explanation :- For manganese ore and chromite the value does not depend exclusively on the percentage of Mn or Cr content, but depends also on the presence of objectionable impurities such as Silica, P_2O_5 etc.

SCHEDULE III

Dead-rent.

The dead-rent shall be uniformly not less than -/8/- per acre and not more than Rs. 5/- per acre for all minerals.

For undeveloped acres and large scale mineral operations the rent charged for shall always be the minimum.

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May, 1951

BULLETIN

OF THE

GEOLOGICAL, MINING AND METALLURGICAL SOCIETY OF INDIA

EDITOR : PROF S. RAY

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BULLETIN
OF THE
GEOLOGICAL, MINING AND METALLURGICAL
SOCIETY OF INDIA

No. 10 **MAY, 1951**

Society's Views on the Mineral Conservation and Development Rules, 1950

The Society welcomes the move taken by the Government in drafting several rules for proper and efficient development of the mineral properties of India with a view to achieving ultimate conservation. The Society feels, however, that this object can only be fulfilled if scientists and industrialists work in intimate collaboration. Supervision and control regarding efficient mining have always to be enforced so that no mineral property might be left in an unworkable condition. The Indian Mines Act takes the safety of the mines and of the labour into primary consideration but is not concerned with prospecting and conservation of minerals.

The development and conservation rules are expected to render help and encouragement in the matter of exploration, development on scientific lines and proper utilisation of minerals.

If the rules in the beginning become too strict and too stringent and bring about complications in development of mineral properties then the very object of development of mineral properties and ultimate industrial progress of the country will be defeated and the capital will be shy in taking active part in mineral exploration and development work. The rules should not be such as to scare away the prospectors from the field of mineral development work. Such a step would lead to definite check and obstruction in the exploration and mineral development work. Minerals being commodities of international trade, the industrial progress and national income of a country will be hampered if the rules stand in the way of mineral development. The Society, therefore, feels that rules for mineral exploration should be of general character and simple in nature and during development and mining work suitable rules for stricter control and supervision should be enforced with a view to achieving conservation of the natural resources.

The draft rules that have been circulated for opinion appear to the Society to be rather elaborate and complicated and at places contradictory to the Mineral Concession Rules, 1949. The rules should be simple and at the same time easily applicable and should attract workers and should offer help and assistance in an encouraging way to the parties concerned. By referring to the mineral industries of the different foreign countries like Brazil, Africa, Australia, Japan etc. it is to be found that mineral industries receive great encouragement and assistance in the shape of technical advice, advance loans (*vide* the Mining Laws of the British Empire, Vol. V, Australia, Pt. II, Victoria, Chapter IV, p. 28), subsides and bounties. The draft rules that have been framed by the India Government have attributed too much power in the hands of one individual—the Director, Bureau of Mines. The Society views with great concern that such dictatorial power vested in the Director, Bureau of Mines may not always function in a faultless manner and might possibly lead to unnecessary harassment of the parties, and it is not known if the Director's decision will always be accurate.

In order to guard against the possible sources of error in individual decision which may not always be very sound the Society suggests that the final decisions with regard to prospecting and development work should rest in a Council with mandatory powers.

Regarding the supervision of the mineral prospecting work it may, if necessary, very well be vested in the Chief Inspector of Mines who with his staff is already doing this supervision in the case of extraction and development work of mineral properties in India. If necessary, additional staff may be secured for this purpose. Any irregularities and violation met with in any operation should be referred to the Council for necessary action.

The Society, while preparing its comments on the several draft rules has taken the the country's interest into primary consideration and has also in mind the idea of offering encouragement to the explorers and mining lessees who will ultimately be helpful to the country in establishing mineral industries. Strict control and supervision of the methods during exploration and development work have also not been lost sight of in these comments, prepared by the Society for the achievement of ultimate conservation of the mineral properties.

The Society has every hope that the comments offered herewith will receive due consideration in the hands of the Government.

The Society may be permitted to mention here that another important aspect of conservation lies in the efficient and scientific utilisation of the minerals extracted from the crust of the earth. Nothing has been mentioned in the draft rules about the efficient utilisation of minerals which, in addition to maximum extraction, will complete the process of conservation.

The Society in conclusion begs to point out that there have already arisen serious complications in the matter of mineral exploration and development work due to the fact that framing of the rules and supervision of mining operations are controlled from the centre by its Bureau of Mines and Mines Inspectorate and the execution of the granting of prospecting license and mining leases are exclusively in the hands of the Provincial Governments. This dual control has given rise to lot of complications and harassment to the parties concerned and due to dilatory methods of Provincial Government departments no remedy or relief has in many cases been obtained by applicants of the prospecting license and mining leases. Moreover, there have been tendencies towards unfair practices in this field of granting of mineral concession which should not exist at all.

In order to overcome these irregularities, complications and difficulties and in order to create a healthy and clear atmosphere in the matter of mineral prospecting and development work it is highly desirable that all matters, *e.g.*, the framing of the rules and regulations, enforcement and execution of such rules and granting of prospecting license and mining leases and control and supervision work relating to exploratory and development work should be entirely done by the Central Government. The Bureau of Mines has already started branch offices in the different States and such branch offices with adequate technical personnel may be easily in a position to execute and enforce the rules and regulations and to grant necessary prospecting license and mining leases to the parties concerned. Of course, the Provincial Governments are expected to render such help and assistance to these Central Government departments as would be necessary for such purposes.

It is therefore high time that India Government should bring all matters relating to mines and minerals permanently under the exclusive control and care of the Central Government without relegating any administrative power to the Provincial Governments regarding such affairs. It is then and then only that the rules framed by the Central Government may be uniformly and equally enforced throughout all the States of India without any obstruction and unnecessary delay.

The Society is finally of opinion that no hasty action should be taken in such an important matter and suggests, therefore, that a select committee be formed consisting of scientists and technical experts and several members of mineral industries to examine in detail the draft rules together with the amendments and to have discussion over the matter before the final adoption of these rules. The rules of the different foreign countries may be consulted in this connection. By way of example it may be mentioned that the interest of the mineral prospectors and mining lessees in Ontario, Canada etc. is amply safeguarded against an arbitary act of any supervising officer leading to cancellation or forfeiture of the licenses which will be quite clear from the following quotations :—

1. *Re*: *Prospecting.*—*Vide* The Mining Laws of the British Empire, Vol IV, Canada, Pt. II, Ontario, Chapter III, p. 16.

Ref: Revocation of License :—

"The minister on the recommendation of the judge may revoke the license if the licensee is guilty of a wilful contravention of any of the provisions of the Mining Act."

2. *Re* : *Forfeiture.*—*Vide* Mining Laws of the British Empire, Vol. IV, Canada, Pt. II, Ontario, Chapter IV, p. 58.

"With regard to forfeitures arising under provisions of the Mining Act, no person other than the Minister or an officer of the Department of question of forfeiture except by leave of the Judge. The Judge may within three months after the ground of forfeiture has arisen and upon such terms as he may deem just grant relief against the forfeiture on terms and on the terms being complied with the interest or rights forfeited revest in the person so relieved."

3. *Re* : *Forfeiture.*—*Vide* Mining Laws of the British Empire, Chapter VIII, p. 71, Vol. IV, Canada, Part. 2, Ontario.

"Whenever a patent or lease of mining lands or mining rights is by proceedings in the Supreme Court at the instance of the Crown repealed or avoided such lands and mining rights thereupon become and are withdrawn from exploration, discovery, staking out, lease or sale and every discovery upon and claim to such lands or mining rights and to the mines and minerals on, in or under such lands made or existing at any time before the appeal or avoidance of the patent or lease become absolutely null and void and the lands, mining rights, mines and minerals are vested in the Crown freed of every claim."

4. *Re* : *Forfeiture, Cancellation, Lapse, Abandonment.*—Vide Mining Laws of the British Empire, Chapter III, p. 64, Vol- IV, Canada, Part III—The Dominion.

"So in Canada it has long been held that where ground is the subject of a Crown lease the forfeiture clauses can only be taken advantage of (*prima facie* and in the absence of special powers conferred) by the Crown and the Crown alone can waive and alone can enter for breach.

The lessee is not liable to ejectment, except in a suit brought at the lessor's instance, or with his concurrence.

Where the mining lessee holds a lease granted under a special Act which lease was expressed as being absolutely forfeited and void *ipso facto* in circumstances which arose such mining lessee remains lawfully in occupation of the ground unless and until the forfeiture is enforced by the Crown.

Cancellation has no retrospective effect and does not make a lease void *ab initio*."

5. *Re* : *Placer Mining Act.*—Vide Mining Laws of the British Empire. Chapter XI, pp. 85, 86, Vol. IV, Canada, Pt. 1, British Columbia.

"A placer-mining lease may be declared forfeited on the non-performance or non-observance of any covenant or condition. The approval of the Minister of Mines is necessary. The ground after declaration of forfeiture becomes open ground."

6. *Re* : *Forfeiture.*—Vide the Mining Laws of the British Empire, Vol. V, Australia, Pt. II, Victoria. Chapter IV, p. 42.

"By by-law 16 it is provided that a claim or tenement or a share or interest therein (except a residence area or business site) is liable to forfeiture, and may be declared forfeited by a Court or a Warden."

7. *Re* : *Granting or refusing application of Mining Lease.*—Vide Mining Laws of the British Empire, Vol. V, Australia, Pt. II, Victoria, Chapter V, p. 57.

"The Governor-in-Council determines on the recommendation of the Minister whether the application shall be granted or refused, the Quantity and shape of the land to be granted, the exceptions, reservations, covenants, conditions and provisos to be contained in leases."

Re : *Termination of Lease.*—P. 71 "If mining operations are not commenced within 12 months following the grant of the lease or if after commencement mining operations cease without the consent of the Governor-in-Council, the Governor-in-Council may on the application of the owner authorise him to re-enter."

8. *Re* : *Determination of Lease*—Vide Mining Laws of the British Empire, Vol. III, South Africa. Pt. I, Transvaal, p. 293.

"The Governor-General shall declare the lease to be determined-"

It is thus evident from what has been quoted above that in the foreign countries a high authority like Minister or Supreme Court or Governor-in-Council is required to take the responsibility of cancelling the license or leases etc. In these draft rules the Government has not taken into consideration the fact that unless very stable rights are granted to the lessee no mining enterprise can thrive in a country.

Regarding cancellation or determination of already existing leases on grounds other than those indicated in the leases will be strictly speaking illegal and as a lease is a form of a contract between the grantor and the grantee extreme care and caution should be exercised to adjudge when such leases will be void and for what particular lapse of the lessee.

Moreover in these draft rules too much power has been relegated to the Director of the Bureau of Mines. The Society however feels that the best method would have been if the power for fine, cancellation of lease or license, forfeiture etc. were vested in a higher judicial authority as has been done in many other foreign countries (vide quotations cited above).

The Society's comments on the different items of draft rules are given below for Government's consideration and necessary action :—

CHAPTER I

Under 2 Add (v) The "Council means, a Board formed by the Government of India, Ministry of Natural Resources and Scientific Research, composed of the following persons—

1. Director of Bureau of Mines (Secretary and Convener).
2. Geological Adviser to the Govt. of India.
3. Coal Commissioner.
4. Chief Mining Engineer, Railway Board.
5. Chief Inspector of Mines.
6. Director, Geological Survey of India.
7. } Two members representing employers.
8. }
9. Representative of the Geological, Mining and Metallurgical Society of India.
10. Representative of the Mining, Geological and Metallurgical Institute of India.
11. } Two representatives from Labour.
12. }

The Director, Bureau of Mines should act as the Secretary and Convener and meeting should preferably be held either in Delhi or in respective States according to the necessity.

CHAPTER II

4. As these information have to be supplied to the Chief Inspector of Mines it seems that it is a case of duplication and can be avoided. The form in which the information are supplied to the Chief Inspector of Mines may be sent to the Director, Bureau of Mines to meet his requirements.

10(b) *Returns for Coal*:

As the return forms regarding coal appear to be unusually elaborate, the Society suggests that copies of the returns as are now being supplied to the coal Commissioner and Chief Inspector of Mines may be sent to the Director, Bureau of Mines for his information.

10(c) Regarding manganese, chromite and other minerals copies of the same returns as are now being sent to the Chief Inspector of Mines may be forwarded to the Director of Bureau of Mines for his information.

The return forms required to be submitted for mica appear to be too cumbersome requiring a great deal of clerical work. In its place it is suggested that the simple return form which is submitted by the Mica Industry to the Development officer, Ministry of Industries and Supply, New Delhi, may be sent to the Director, Bureau of Mines for his information.

CHAPTER V

25, 26, 27, 28.

As prospecting and mining of mica cannot be clearly differentiated and as prospecting licenses are not granted for mica these rules should not therefore be applicable to mica.

25. This rule should be as follows :—

"The holder of a prospecting license for any mineral shall, during the tenure of his license, investigate systematically by drilling, sinking trial shafts, trenching and such other operations as are considered necessary by the Prospector or his technical staff, the correct underground disposition, shape, size and average grade of the ore body intended to be worked."

26. *Delete*, because it is the holder of prospecting license who should be the person to be satisfied and not the Director, Bureau of Mines, for starting mining operations. The right to a mining lease awarded by Rule 24 of Mineral Concession Rules, 1949, should not be withdrawn by another new rule.

27(1) *Delete*, as it is opposed to Rule No. 56 of the Mineral Concession Rules 1949, which gives a clear right to start mining.

Moreover this rule 27(1) is not applicable to many cases e.g. to the old mining lease holder and to several cases of coal and other minerals where surface indications are sufficient enough to warrant immediate mining operations.

27(2) *Delete*, because mining lease under Rule 56 of the Mineral Concession Rules 1949 gives a clear right to mining operations; once the right to mine has been granted no new rule should be framed to take away that right.

CHAPTER VI

31. In the 4th line in place of the word "direct," substitute the word "suggest."

At the end add the following :—

"provided such alterations are feasible and are within the means of the parties concerned."

32. *Delete,* as it is in contravention to the rights of the lessee obtained under Rule 56 of the Mineral Concession Rules, 1949.

Moreover the right of the Director, Bureau of Mines, is already given in Rule 31.

33. After the word "to" in the 2nd line add the following :—
"economic and within the means of the party concerned."

CHAPTER VII

35. *Delete.*

41. After the word "operations" in 2nd line add the following :—

"which may be economical and within the means of the parties concerned."

CHAPTER VIII

42. *Delete,* because the Society feels that there may be difference of opinion as to when suitable stage of development has reached before stoping could be done.

43. After the word "Adequate" in the 2nd line add the following :—

"under normal circumstances."

43(2) and 16.

It is mentioned in Rule Nos. 16 and 43(2) that Director's decision is final. It appears that such power if given to the one individual may sometimes lead to confusion and harassment of the parties concerned. It is suggested that "Council" for different important minerals be formed with mandatory powers. The Directer, Bureau of Mines, shall be required to report cases of irregularities and violation of rules to this "Council" for disposal. The order of prosecution wherever necessary shall be issued by this "Council."

There should be provision for appeal against the decision of this "Council" before the High Courts of the respective States.

CHAPTER IX

48. After the word "Director" in the last line add "or Chief Inspector of Mines."

49. After the word "Director" in the last line add "or Chief Inspector of Mines."

54. After the word "Director" in the 2nd and last line add "or Chief Inspector of Mines."

55. After the word "Director" in the 1st line add "or Chief Inspector of Mines."

55. In the end add.—

"This rule may be relaxed if proper stowing process is adopted to leave the other portions of the seam to be worked in future."

56. In the last but one line add after "cases" the following—"where stowing has been introduced."

CHAPTER XI

64. In the 1st line after the word "require" add—"in cases of emergency."

65. At the end add the following.—

"provided the whole process is economical and within the means of the parties concerned."

66. in the 5th line after the word "time" add the following.—

"provided the whole process is economical and within the means of the parties concerned."

CHAPTER XII

67, 68, 69, 70,71.

The penalties mentioned in Rule Nos, 67-71 appear to be too severe and in the opinion of the Society will retard and check the progress of mineral exploitation work in the country.

The Society however suggests that penalty in no case should exceed the penalties prescribed in the Indian Mines Act. It is desirable that rules regarding mines and minerals should be uniform in the country.

72, 73 and 74.

Regarding prosecution and court of trial the Society suggests that the convicted parties should have right of appeal against the conviction in the High Court of respective places.

SYMPOSIUM
ON
INDIA'S MICA INDUSTRY

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SYMPOSIUM ON INDIA'S MICA INDUSTRY

FOREWORD

When the Government of India was reconstituting her Mining and Mineral Concession Rules, after India had gained freedom, the Society felt that the problem of the Mica Industry which is a major dollar-earning industry in India, should be presented to the country and her Government in very clear terms.

The best way to assemble opinion on this point from members of the Society who are intimated with the industry in one way or another, was thought to have a Symposium on the topic.

Members were requested therefore to meet with their opinions in a series of four meetings held between 16. 9. 50 and 5. 5. 51 at Dhanbad, Kodarma, and Calcutta. As many as sixteen papers were read and discussed in these meetings by members who feel deeply interested in the Mica Industry. These papers are included in the present Bulletin No. 11 of the Society. They deal with the different aspects of the Mica Industry and has here been classified primarily for convenience of reference into the following sections :—

I. Problems of the Mica Industry.
II. Problems of the Mica-pegmatites.
III. Problems of Mica Mining.
IV. Synthetic Mica.
V. Chairman's Note on the Mica Industry.

An extensive field has been covered in these papers and the relation of some of the authors with the Mica Industry has been very intimate. As such this Bulletin should find the attention of those interested in Mica and its industry as also of our Government.

I have been particularly attracted by the article by A. N. Kalia on Geological Mapping in the Bihar Mica Field in Section II of this Bulletin. The discussion opens up a new perspective. Should we not pause to think whether the plan of study proposed will be rightly helpful both for the scientific study and for the industrial exploitation of the Mica-pegmatites ?

THE MICA INDUSTRY IN INDIA

BY

D. B. Sahana

Mica is a national asset of great value. It is needless to add that mica is also a wasting asset and can not be replaced once it has been taken out. Therefore, utmost care should be taken in the mining of this mineral which should be done in an intelligent and scientific manner, so that the mineral deposit may be exploited thoroughly and not in a haphazard manner, for the larger interest of the Nation. It is not uncommon to find in periods of temporary boom in the mica market that hundreds of people are let out on a mica property and they simply pick out the eyes of the mines resulting in almost complete defacing of the surface signs on which depends largely the future development of a mine. It is gratifying to find the Inspector of Mica Mines taking a keen interest in the matter but the Inspectorate is utterly understaffed with only one Inspector for an area of more than 100 sq. miles situated in difficult and roadless country. The total number of reported mines both large and small are at present about 700 in number and one Inspector with at least four assistants are required to supervise effectively the mica mining area in Bihar. We hope the Government will take note of the requirements of the mica industry in this respect.

About 80 per cent of the crude mica raised from the mines is thrown away in mica dumps and are regarded as waste mica or mica scrap. This in its turn is exported to foreign countries at very low prices, mainly to the U. S. A. and U. K. for conversion into ground mica. There is absolutely no reason why the grinding should not be done in India. In that case, India can supply the world with the finished product instead of the raw material. Grinding of mica is done either by the dry grinding or the wet grinding process. Very fine mica powder, say upto 300 mesh, can be obtained by the wet grinding process. The grinding of mica does not require much capital outlay but it requires technical skill. Given the opportunity and scope, there is no reason why our youngmen should not learn the technique of mica grinding. I would suggest sending a few young men having advanced knowledge of applied chemistry and physics to America for getting them trained in mica grinding mills; of course the matter can only be dealt on a government level. We have also jute bags produced in our country for packing the mica powder. Other countries are lacking in this facility. There is an excellent opportunity of turning out our waste mica into finely ground mica, but there are hurdles to cross particularly for a country which has recently gained its freedom.

Secondly, India holds the monopoly in the manufacture of mica splittings. Mica splittings are used, amongst others, in the manufacture of micanite sheets. We have the two components of micanite in abundance in India viz:-mica splittings and shellac, the bonding material. It will be an act of adding to the national wealth, if we could use both these indigenous substances and could turn out micanite, so that we could supply the world market with the finished product instead of supplying the raw materials as done hitherto. Attempt in preparing micanite in India should be made with the lowest quality of splittings viz., No.6-3rd loose, the selling price of which is at present-/12/-to Re 1/- per lb. And then when found successful in this item, higher qualities such as No.6-1st loose and No.6-2nd loose can be used in the micanite factories of India. Here also State help is necessary in advertising the Indian product abroad and its sale amongst the consumers overseas. It is more on planned utilization that the industrial expansion of a country depends than on anything else, and I am confirmed in my belief that much can be done in the way of utilization of mica provided the required amount of help is forthcoming from the Government of India.

Lastly, I would like to mention that while comparing figures of mica production between 1948 and 1949, a fall in production is noticeable. There may be several factors contributing to this undesirable state of things, and it is imperative in the national interest to investigate into the causes and to find out suitable remedies so that India may still retain her predominant position in mica in the world market. The appointment of a Commission on the lines of the Coal Commission is called for to examine the problems of this important dollar-earning industry without further loss of time.

INDIAN MICA : SOME ECONOMIC & STRATEGIC ASPECTS

By

B. P. AGARWALLA

The impetus of the war, it was feared, may lead to a discovery of substitutes for mica. Fortunately, however, no suitable substitute for mica has as yet been found. India's unique position as a mica-producing country remains unaltered, a fact that should be fully appreciated from the economic and strategic standpoint. High grade mica is India's monopoly in the world. But this enviable position has not been fully exploited. In the past, the brokers in London and New York, by means of a close working agreement among themselves, dominated the world mica market, so much so, that there was an unwarrantable increase in price at the consuming centres over the producers' prices at the pits' mouth. This anomaly was sought to be removed through establishment of direct contact with the consumers by the chief mica-producing firms. But despite these efforts, London continued to dominate the world market in mica because, probably, of the inability of the mica producers to replace the brokers with the latters' expert technical knowledge from the consumers' point of view, because of the want of an organised Marketing Board and also because of India's politically dependent status. Conditions are now favourable and the Government of India should henceforth evolve a mica policy in order to ensure the country's proper position in the world mica market.

The setting up of the joint Anglo-American Mica Mission in India during the war is significant, strategically. The mineral is indispensable in the electrical industry. The absence of suitable substitutes for mica (Indian mica) confers on India a greater measure of strategic importance. To what extent and how this position can be utilized to the country's advantage is a subject for expert investigation. But it needs no special knowledge to emphasise that hard bargaining in our foreign relations, vis-a-vis mica should be avoided. For, it is under difficult conditions that human ingenuity finds best expression. Shortages during the wars have led to the discovery of the substitutes. Shortages created by the imposition of excessively difficult conditions may also provide the necessary impetus for finding out substitutes.

Economic and strategic consideration must form the basis of any mica policy that may be formulated in future. It is by virtue of the quality and reserves of the mineral that India holds her monopoly in the world mica market. It is important, therefore, that a clean idea of our reserves of mica should be formed. This, unfortunately, is impossible in the confusion created by the Indian geologists holding tenaciously to two sets of theories about the origin of our mica deposits. According to one set of theories—the leaching out and the absorption theories—the deposits are shallow ; according to the other—the pegmatitic-pneumatolytic theory—our mica deposits are deep-seated. The difference in reserves estimated on the basis of these theories will be very great. To under-estimate our reserves will be as indirect as to over-estimate them. Our geologists should resurvey the mica fields and try to establish a theory, commensurate with the available data, about the origin of the mica deposits. Dogmatism in any form must be avoided, if not for scientific reasons, at least for patriotic reasons.

The Mica Enquiry Committee emphasised the need for conservation of mica and avoidance of wasteful methods of mining. The wasteful 'uparchala' method of mining is sought to be justified by interested persons in that the 'uparchala' workers are the pioneers and have discovered important lenses which subsequently developed into full-fledged mines. But the argument is untenable. The incalculable harm done by the 'uparchala' workers more than offset the very doubtful service renderded by them to the mica industry. Besides, if India is to prosper, experts only, and not pretenders to technical skill, should play a part in shaping the future.

CERTAIN PROBLEMS FACING INDIA'S MICA INDUSTRY

BY

N. N. CHATTERJEE

It is good that the Society has organised a Symposium on India's Mica Industry and that several articles have already been contributed dealing with various aspects of the subject. It is hoped that the present deliberations would produce a true picture of the mica industry and its problems such that ways may be found out to overcome these difficulties for placing the industry on a better footing. It is also hoped that some initiative would be taken by the Society to achieve this end so that better and healthier conditions might prevail in the atmosphere of the mica industry of India.

I had the opportunity of visiting Hazaribagh, Nellore and Rajputana mica belts and from my past experience in these areas I am going to refer to certain problems facing India's mica industry and would like to touch on its geological, economic and commercial aspects.

In the first place, let me discuss the problems of its total reserve, its maximum extraction and its proper utilisation which are linked up with the question of conservation.

RESERVE

It is absolutely necessary that we should possess sufficient knowledge regarding the reserve of the mica deposits and this is a subject which gives lot of headache to the geologists and the mining engineers. On account of the irregular manner in which the mica bearing lenses are found in the pegmatites it has always been very difficult to make an accurate estimate of the reserves of mica in the different pegmatites. Moreover, the lenses pinch out so often in both directions that it is sometimes very difficult to trace the continuation of one lens into the next one and it is for this reason that at many places the working company had to abandon the mine. There are again instances where another company taking over the property from the previous owner, through luck, could strike at another promising lens which contained plenty of mica books of good quality and of high market value within a short distance from the abandoned pocket. Such being the mode of occurrence enough exploration and development work would be necessary to prove the different mica lenses in a pegmatite. It is, therefore, suggested that the owners who are working the mica mines should always set apart certain amount of money for such exploration work as could be deemed necessary for each mine. It may not always be possible to invest big sums of money for exploration work by owners with small capital and in that case attempts may be made to persuade these small mica mine owners to combine and amalgamate so that bigger economic units may be formed which would help them in a co-operative way to continue mining mica in a much better and improved manner. At the same time it would be possible to do considerable amount of exploration and development work knowing full well that in many cases such exploration work may not give any return at all. But such investment would seem to be very helpful for the purpose of proving the known deposits in a more precise manner. From what has been said it is quite clear and apparent about the uncertain nature of the mica deposits and it it thus really a difficult problem to make a correct estimate of the probable and workable deposits of mica in a particular area.

CONSERVATION

Regarding conservation of these mica deposits the reserves of which are not definitely known, we have to follow the general principle i.e., to have maximum extraction and to avoid all possible wasteful process of utilisation of mica.

MAXIMUM EXTRACTION

Regarding maximum extraction it may be pointed out that by the crude method of working that is prevalent in many of the smaller mines it is not possible to have the desired maximum extraction and steps should be taken to persuade the owner to carry out systematic mining operations with the help of qualified mining engineers, so that better conditions might prevail in the mica mining world. Those who have personal knowledge of the conditions of mining in the mica areas of India will support me when I say that this industry is one of those where very few qualified mining engineers were employed for extraction of mica from underground and this might have been one of the reasons for inefficient and unscientific methods of mining prevalent in the different mica belts, formerly under the supervision of nontechnical men with only experience of local conditions. I think this state of affairs has now slightly changed and that many of the companies have in their employment several qualified mining engineers in charge of the mica mining. There may be even now many small mica mines which are run by local people without the help of any qualified mining engineer. To such mica owners who find it difficult from financial standpoint to employ qualified mining engineer my suggestion would be to amalgamate with other small owners and to form bigger economic units so that efficient and up-to-date mining methods may be introduced with the help of qualified geologists and mining engineers. Such attempts would not only do them good but would also contribute to the country's welfare. By such up-to-date methods better extraction of mica would be possible with safety and further exploration work might also reveal new pockets or lenses containing marketable mica books of value. Arrangements should be made as early as possible for the training of Mica Mine Managers as already recommended by the Mica Enquiry Committee of 1943-44 for supplying trained personnel to this industry.

PROPER UTILISATION

Regarding utilisation of mica it is needless to mention that proper utilisation should be the guiding principle for the consumers to see that there is no waste in the matter of utilisation.

PROCESSING

Regarding processing I have to refer to the grading in sizes and quality for the overseas market. From a reference to the different standard grades of size and quality I may point out that it is sometimes difficult to classify the pieces in the different quality grade with greater amount of accuracy by visual tests alone.

Same pieces of mica may be classified in one or more quality grades by diffierent sets of experts. My suggestion would be to standardise the quality in a more precise and scientific way so that the grading may be done quite easily by up-to-date electrical testing methods even by the less experienced people. It is quite clear that as India has to export all her mica production to foreign countries she has to adopt the requirement of the buyer as regards specifications and grades into size and quality. Unless India starts manufacturing electrical goods and heat-insulating articles in this country, she will have to satisfy the buyers' demands, but the revision of the standards regarding size and quality may be done by producers and consumers in consultation. Indian Standards Institution, recently started in India, would be in a position to help the mica Industry in this respect. So long as India does not manufacture electrical goods it may be suggested that she can in the meanwhile process the mica in such a way as to fetch better price than by simply exporting the books. In India labour being very cheap the processing may be done with greater advantage and economy. There is another trade in which India can specialise, namely, the introduction of the grinding of mica scrap and exporting them as ground mica or to utilise this ground mica for the manufacture of built up mica or micanite for various purposes. It is highly desirable that instead of importing electrical goods from foreign countries serious attempts should be made in India to start manufacturing electrical machinery and heat-resisting appliances so that domestic production of mica might have immediate use in such industry.

SYNTHETIC MICA

Another serious problem facing India's mica industry is the threatened competition from synthetically produced mica. Already serious attempts have been made within recent years particularly in Germany during the last war, but so far proper substitutes have not yet been found to replace mica in the various machineries. It is thus seen that the manufacture of synthetic mica is no longer a matter of imagination. An extract from the Queensland Government Journal, September 20, 1950, given in a subsequent paper shows how seriously the scientists are at this attempt. We do not know if a synthetic product can be obtained in near future with all the chemical, physical and electrical properties of the best grade of Indian mica. To safeguard the interest of the domestic mica industry we should take sufficient care to classify mica according to quality and to put them specifically to proper uses. It is therefore suggested that both the mica industry and the Govt. of India should be forewarned about the situation and steps should be taken to guide the trade carefully so as to satisfy the consumers' requirements in the best possible way.

MICA THIEVES

This has been giving lot of trouble to the mica industry and due to this the returns for production figures have always been vitiated to some extent. There had been certain legal measures taken but I think this evil has not yet been quite eliminated. The mica industry with the help of the Govt. should put a check to it and according to some information, it is understood, that some stray and small mica dealers support these nefarious activities and if the small owners are made to amalgamate, this condemned practice may be removed, doing good to the country's mica industry and trade.

MARKETING

We sometimes hear of huge dumps of exported staff at the wharves of foreign docks and our mica exporters are put to a helpless position and ultimately had to yield to the lower prices dictated by the foreign buyers. This sort of shipments and consignment without getting definite orders should not be encouraged and both the trade and the Government should give a very careful thought over this matter so that the national interest may not suffer. It is also desirable that better trade relations should exist between India and other foreign countries and for the achievement of this end the industry should receive help and co-operation from the Government.

NATIONALISATION

If proper and systematic mining is not followed and in case proper utilisation is not adopted, there may be suggestion from certain quarters to nationalise the mica industry and that India Govt. should take upon itself the task of running the mica production and marketing. From our experience we can say that it would not be wise to ask the Govt. to do it as it would not be always possible for the Govt. to run it economically. It is, on the other hand, suggested that private enterprise should be allowed to thrive in this direction and all facilities and technical advice should be given to those who are involved in this difficult task of mica mining and there should be arrangements for proper control on the mining and extraction methods and supervision in the matter of processing and marketing so that the India's mica industry might be placed on a sound and more stable footing.

GOVT. CONTROL

Lastly, I would like to point out that this key industry of India had been under the direct control of the Central Govt. as well as of the various Provincial Governments and that several portfolios of the Central and Provincial Governments have been dealing with this industry in its different aspects. This sort of varied control from different sources had always been an interfering element and instead of encouraging the industry to develop in a more healthy way it had been considered to be a check on the proper growth and development of the industry. In order to do away with this sort of anomalous position with regard to administration of the mica industry it is suggested that this industry should be brought under one unified control from the Centre and the same type of rules and regulations and supervision measures should be applied in all the Provinces where mica occurs, and in order to do that the Provincial interference of any kind or, in other words, the autonomous control of this industry by different Provincial Governments should altogether cease and the subject of mica mining and all affairs regarding mica trade and industry should be completely centralised for the proper development of the mica industry of India.

POPULAR FALACIES IN THE MICA MINING INDUSTRY OF BIHAR

BY

A. N. SRIVASTAVA

We all know that the Mica Mines of Bihar meet 70% of the civilized world's demand of the strategic mineral mica, but the workings of these mines are primitive. We are also aware of the fact that the use of mica is indispensible for the elecrtical industry, but electricity has been sparingly used in the mica mines. The pegmatites of Bihar yield the richest deposits of mica, but the Geological Survey of India has done but little work on them and the mica which they contain. The locality where mica occurs has been so much neglected by the State Governments that the conditions of roads are awful, inspite of the fact that this mineral is not only responsible for a good amount of revenue by way of several taxes, but also it earns foreign exchange for the country.

The object of this paper is to describe some of the popular falacies which have stood in the way of the progress of this important industry. The falacies are (i) technically qualified personnel is of little or no use to the mica mines, (ii) the life of mica mines is extremely short, (iii) greater mechanisation and use of electricity is not advisable in mica mines, (iv) the rock in close proximity to the pegmatites is always the schist (locally known as Tilkut), (v) the rocks which constitute the pegmatites have no bearing on the quality of mica books in any particular vein. These are the views of both big and small in the industry. I would take them one by one. In addition to the above there are many falacies which are popular with the uneducated local men, such as, (1) pegmatites fell on the earth from the heaven, (2) small mica would grow bigger in size if it is not extracted, etc. etc. which need not be discussed before this educated gathering.

(i) Technical personnel—The mica mining industry suffers greatly from want of technically qualified persons. There are hardly 8 or 9 mining engineers in the whole of mica field comprising of about 600 mines. Excepting one mining firm, none of the big 4 or 5 employ a mining engineer. This apathy towards technical personnel in mica mines is adversely affecting (a) nation's reserves of mica, (b) the interest of owners of mica mines, (c) the safety in mines, and (d) the interest of labour.

(a) Nation's reserve—The primitive and haphazard methods of working in mica mines are as much proverbial as the much advertised thefts. Every year a large quantity of mica is wasted or left underground, by the unscientific methods of working, never to be extracted. There are cases where big mines have been spoiled in erroneous search of the payshoot by persons who had little knowledge of geology. In some mines the directions of dip and strike have not been determined even after years of work. Nobody has cared to study the surface indications and the surface topography which solve many a problem of mining. In massive veins where the dip of hanging and foot-walls is gentle, or is not clearly defined, the workings are so irregular that stoping has become difficult, if not impossible.

The 'Korkat' system of prospecting prevalent in mica mining area is fast losing its use and importance as the days of superficial scratching are coming to an end. It is true that most of the mines were discovered by the above methods of prospecting, though the illiterate staff could not make the best use of the trial pits in determining many important data which go a long way in successful exploitation of a mine, but it is also true that many a good mine has been spoiled by the system and a large quantity of mica has been buried for ever.

(b) Owners of mica mines—From the point of view of owners of mica mines greater efficiency in work by reduction of cost of production and stoppage of theft can be achieved only by employment of qualified engineers. Regarding theft in mines, nobody knows it better than the mine owners themselves that all big thefts are committed in the knowledge and with connivance of the mines staff and the Divisional Heads, whereas the labour is generally responsible for small pilferage. In many cases the Divisional Heads are the relatives of the top-men of a company.

(c) Safety in mines and Indian Mines Act—For better enforcement of safety regulations in a mine it is necessary that qualified men be appointed to be 'Incharge'. The owners of mines have nothing to lose by enforcement of these laws. The person who is responsible for violation of the Act is the supervising staff, who neither understands the meaning nor the value of safety regulations. He is not afraid of prosecution as well, unlike an educated man.

(d) Interests of Labour—In order to improve the conditions of labour the first and foremost step is to make it obligatory on mine owners to employ educated persons inspite of their past and present prejudices. The Mica Mines Welfare Organisation—Ministry of Labour Government of India is being very much handicapped for absence of good educated and honest persons in deep forest areas where the mines exist. Some owners and their staff feel that the Government is trying to encroach upon their rights to deal with their labour and a few others feel that if the labour become conscious of its present condition, trouble would arise. They therefore do not carry the message of the Welfare Organisation to the labour who fail to take advantage of the welfare activities of the Government.

(ii) Life of Mica Mines—The common belief among the mine owners is that the deposits of mica are extremely limited and the size of payable veins is such that it does not justify use of machineries. From the data at our command at present we find that hundred years have lapsed since the mica was first extracted for the purpose of export, but the maximum depth which the deepest mine has touched is not more than 500 feet. The average depth would however not exceed 150 feet from the surface. Many mines which were once abandoned as being unproductive are again producing good quantity of mica. After so many years of work there are still virgin fields, where no work has been done beyond the prospecting stage because of inaccessibility. Uptil now we have been doing superficial scratching only. In words of Mr. Dunn "veins have been worked down to a depth of 500 feet but because any individual vein thins out at that depth there is no reason why adjacent veins which may not have reached the present surface should not continue to a much greater depth". The conditions which apply to the lateral extent of a lenticular vein also apply to their vertical depth. For a geologist there is nothing at present to prove that the veins would not stretch beyond the level to which they have been presently worked.

(iii) Greater mechanisation and use of electricity—In mica the art of mining has never been much associated with the science of Engineering, a fact which has led to uneconomical working entailing huge waste of Nation's wealth at a time when the world has been busy in conservation of their natural resources by decreasing avoidable waste to a minimum. Everywhere the trend in mining is towards more and more mechanisation. This increased use of machinery to replace hand labour has been assuming many new forms with electricity. In mica mines the power required for driving machineries is compressed air and sometimes steam. The use of electricity, the efficiency of which is many times higher than that of compressed air is almost unknown. The efficiency of a few machines used at present is extremely low. The drilling efficiency is very poor because of the absence of proper Jack-bits. 1 to 4 drill rods generally of the same size are applied for a round of 15 to 20 holes. Flat-end drill bits are used generally. There is no efficient machinery to handle muck. Small hoists in some mines work as haulage engines which too have their limitation because of the fact that underground roadways are not properly designed. Mines depend on natural ventilation even in deep mines. Because of the facts mentioned above the cost of footage drilled and advanced is very high and hence the owner finds it generally prohibitive to proceed when he strikes a barren point. The conditions of coal mines before 1910 can well be compared to mica mines of the present day. I am quoting here from the History of improvement in method of mines with the use of electricity in India, "As underground workings went to greater depths the sizes of pillars were necessarily increased, but it also became customary to make the galleries from 10 to 15 feet in width. The arrangement for pumping out water played an important part in the layout of workings and the productive capacity of mines. Steam pumps became necessary, but their limited range of operation involved the winning of a high percentage in first workings. It was also the use of such pumps which were comparatively inefficient and a constant source of trouble and anxiety to the management that caused much of the pillar robbing, because when a break-down occurred and deep working faces were flooded, output had to be maintained by dressing and robbing pillars or by removing roof or floor coal from galleries."

"For the development of deeper workings with the necessarily greater lengths of underground haulage and pump lines, electric power at once comes into consideration with the alternatives of a power supply company or a private installation. Upto the year 1911 five companies had installed their own generating plants with a total capacity of 1500 Kwts. Thus from about 1910 the introduction of electric pumps with increased efficiency, unlimited range of operation and greater reliability brought about a gradual change in mining method and allowed the formation of larger pillars............The introduction of electrical machineries into mines has had such striking effect on the lay-out of workings and the reduction of pillars that a clear line of demarcation can be drawn on many mine plants of the workings before and after the general discontinuance of the use of steam."

By using electricity for purposes other than drilling, mica mines can be worked effeciently without break down under depths. Greater mechanisation with help of electricity would so much reduce the cost of footage drilled and advanced that the mine owners would easily proceed with the search of mica when barren points would be encountered. For small mines also mechanisation is necessary. Hand mucking, hand drilling and hand tramming should all be eliminated with the help of suitable mechineries. In mica mines one thing which is worth notice is that a mica mine owner generally works more than one mine in one particular field. There are many cases in which a particular mine owner in a particular field works more than six mines. For each of these mines he has got separate Diesel engines for driving his compressors. It is nothing but his conservatism which has stood in his way of installing electric generators for supplying power for his group of mines. It is now a common knowledge that the most economical method of distributing power about a mine or a group of mines, or, in fact, any works occupying a large area, is by generating electricity at some convenient place, as central as possible.

At not a very distant date mica mines would be getting power from the Telaiya Dam but even then installation of individual generating plants (of course in case where it is not possible collectively) is quite justifiable because of the saving that would accrue per man day. For those who are going in every day for costly Diesel driven compressors. the installation of Diesel generating sets is more advisable.

(iv) Rocks in close proximity to the pegmatites—Though mica schist locally known as *Teelkut* is the country rock enclosing the pegmatites, it has many a time altered into gneisses by recrystallisation under the action of magmatic solutions which have permeated through the schists. I have come across gneisses which vary in thickness from a few inches to more than 100 feet. These gneisses require a close study as they are of great help in locating the veins and the payshoots. Another rock which is many times found in the close proximity to the vein-wall is the friable tourmaline-garnet-mica rock locally known as *Kuchath*, meaning massive. In addition to the above, greyish white mottled grey and pinkish gneisses are exposed at several places in contact with the pegmatites. These gneisses are the original metamorphic rocks of the Archaean age and have not altered from the schists.

5. Factors which influence the quality of mica. There is a vast field for research on the conditions which have resulted in the formation of different grades of mica. Among the many factors which have probably influenced the depostion of different grades of mica, the two most important factors would have been the chemical composition of the magma and the enclosing schists, and the conditions under which the magma crystallised. Both these factors would have also influenced the deposition of constituent minerals in the pegmatite vein. I have noticed that the clearer variety of mica invariably comes from the quartz core in the pegmatite vein channel. The mica which is found embedded in the plagioclases in between the quartz core and the schists is generally of the second grade. This is not true, however, if mica has been formed by the replacement or re-crystallisation of the schists, or if the massive tourmaline-garnet-rock is found on the vein-wall, which is suggestive of abundance of volatile matter. In these cases heavily stained variety of mica are found.

In a few mines very big books of mica of the stained quality are found in interstices of white or rosy quartz core separated by fine layer of albite. The size of the book depends upon the size of gap between the quartz pieces. It is probable that in this case the muscovite forming solution filled the interspaces of the quartz under pressure after the latter has crystallised, and the soda in the solution has formed the fine layer of albite.

The quality of mica depends also perhaps on the composition of the country rock enclosing the veins. In those cases in which the schists are brown coloured garnetiferous sillimanite schists or dark coloured biotite schists the mica found in the vein is of the poorer quality. In light coloured muscovite schists or tourmaline muscovite schists better grades of mica have been formed.

As I have already pointed out there is vast field for research on the pegmatites. The physico-chemical factors which have influenced the formation of different grades of mica are themselves big problems for research not from only the academic point of view but also from the point of view of economic geology and practical mining. It would be preposterous on my part to try to answer the complexities of mica-bearing pegmatites without their proper study in petrological laboratory. I have tried to give a few facts stated above from the field study of the rocks only.

BIHAR'S MICA INDUSTRY

By

L. A. N. Iyer

The mica industry of Bihar is of enormous importance to Bihar, India and the World. 70% of World's sheet mica comes from India. Bihar's ruby mica is regarded as the best mica for electrical purposes.

Mica was known in India from time immemorial. '*Abrak*' (Sanskrit--Cloud) was used for medicine, ornaments, decorations, glazing or as a transparent medium, etc. According to Hindu Chemistry, it was treated as one of the '*Rasas*'.

Traces of mica mining have been recorded in India since about 2,000 years B. C., but no systematic history of the development of the mining of mica in ancient India is available. Modern mica industry started about the first quarter of the 19th century, if not still earlier. The first traceable record is that of Surgeon P. Burten (1826) who said that large transparent laminae were obtained a few miles east of Hazaribagh Rly. Station. In 1849, Dr. M. C. Lelland described mica mines near Dhanbi Dhoba (Dhanbad) and Quadrumme (Kodarma). At Dhanbi about 50—100 men and boys were engaged in the mines and women and children were occupied in sorting and dressing of the plates. 10,000 maunds of mica were sent to Calcutta and sold at Rs. 7/8/- per maund. Other mines produced more mica and it was sold at Rs. 4/- per maund. Capt. Sherwill (1851) speaks about the mines of Dhanbad and Rajauli (Gaya Dt.). They produced 14 tons of mica. Statistical accounts of Bengal (1863) record export of 10 000 maunds of mica at Rs. 3/- per maund and Rs. 30,000 were realised. 7,500 lb. of mica was sent to England. From 1884, mica exports were more or less regular and entered the international mica trade.

Towards the close of the 19th century, there was rapid development of the electrical industry in U. S. A. and Germany, and the demands for mica as an insulator for electric and heating purposes grew up by leaps and bounds. This demand stimulated increased production of mica in countries then known to possess mica, e. g. India, Canada and U. S. A. The Madras field was discovered in 1887.

According to information obtained from Mr. F. E. Chrestien, the son of Mr. F. F. Chrestien, in 1942, his father started mica mining 54 years ago, i. e., about 1888. His first attempt at Bairia near Tisri had failed as there was no market for mica. He had come back after 10 years and arrived at Mahesri, Bairia and Kodarma, but not in Gawan. One Mr. Boddam was the first European to try at Gawan his luck in 1890, but he failed. Then, Mr. F. F. Chrestien took a lease and he was successful. He was at Tisri in 1888, and started work there and the mica came from Bairia, Bhandari, Kodarma, Musnodi and Mahesri. A lot came from Mahesri in those days. By 1894, his business was fully established. In 1900 Tisri was a nature place and mining was in full swing in Gawan under Sir Hugh Hanay who afterwards became agent of the E. I. Rly. In 1899 M/S. F. F. Chrestien & Co. operated 110 mines, Raj Krishna Sahana, 31, and W. R. Macdonald, 28. Before 1900, manufacture of splittings had begun, It revolutionised the mica business. The methods of mining were primitive till 1908, when Mr. F. E. Chrestien took over at the age of 26 years. Mica industry was in a slump then. For many years Gawan played a second place to Kodarma. Since the latter produced electrical mica almost entirely. Singhe, Bairia, Dhawapat, Lakarmandva and Pachrukhi had all great reputation. Mr. F. E. Chrestien tried at Dhawapat and Pachrukhi and failed. Then in 1910, under Mr. F. E. Chrestien's guidance modern mining was introduced and the Company flourished and expanded from stage to stage. Other firms also entered the Micafield as Sunder Mal's India Mica Supply Co. Ltd. and also Tatas, Hoare, Miller, Bird & Co. etc. After the World War I, Tatas and other European mica miners withdrew and only two English concerns were engaged in mica mining—M/S. Chrestien and Co. and John Podger and Co. Since then, mica mining flourished under Indian-Companies, e. g. M/S. C. H. and Co., India Mica Supply Co., Sahanas and a number of other concerns. With World War II, Podger's concern was liquidated and M/S. Chrestien and Co., was bought by M/S. Aggarwal Bros. Now, therefore, the mica Industry is entirely owned by Indians : a very satisfactory stage in the history of the mica industry,

THE BIHAR MICA FIELD

It is about 90 miles long and 20 miles wide. The Kodarma Reserved Forest has 900 squares of 40 acres each in area. In 1939, 400 squares were leased for a period of 30 years. Originally mica leases were at 5% royalty on the Pit's mouth value of the mica. It was then changed to a dead rental value for convenience at Rs. 1/8/- per acre, Rs. 3/-, Rs. 4/8/-, Rs. 6/- and for new leases Rs. 12/- per acre and as. -/4/- per S. D. B. cess to the Dt. Board. Of the 400 squares leased in 1939, not more than half were mined. Zamindars hold the mineral rights in Zamindari lands. They may mine the mica or lease their areas to mica miners. Several hundred square miles have been leased and the terms vary from property to property.

Probably 25% of the mica of the Bihar mica belt is produced from surface workings, known locally as '*Uparchalla*' workings which extend to 20 ft. depth. Underground mines, 150-200 in number and varying down to 500 ft. in depth, came under the Indian Mines Act. About 14 of these mines supplied 30% of the mica. Up to 1928, most of the mica was obtained from' *Uparchalla*' workings or shallow mines, which were never worked systematically. First many mines were abandoned due to water trouble. Later, machinery was introduced and the water problem could be tackled. All of the larger mines have been mechanised.

MICA AND ITS SPECIFICATIONS

The mica is separated from the rock and bad portions removed ; it is then sent for cutting and sorting. Books of mica may vary from a few cubic inches to big blocks of 200-300 sq. inches in the plane of lamination and one foot or more across. They are dressed by sickles and are hence known as S. D. B. These are graded according to size and these various sizes are in turn sorted according to clearness, hardness, flatness, colour, size, air inclusions, vegetation and mineral stains. We thereby get blocks, chillas and waste. Blocks may be exported as such but may also be produced into splitting, wrappers, condenser films and plates, washers and discs. Women and children do the splittings.

Mica is irreplaceable in its applications and as such constant and ample supply is indispensable for the maintenance and development of the ever-growing electrical, radio, wireless and aeronautical industries. Uses of mica prescribe separate specifications according to the specified object for which mica is needed. Electrical mica has to be selected with particular care in regard to the dielectric strength, hardness and thermal resistivity. The agreed specifications are :—

1. Degree of clearness as specified. 2. Freedom from imperfections. i. e. foreign mineral matter and inclusions. 3. Easy splittability and freedom from wedges, cross-grains (*'Jatai'*). 4. Degree of flexibility and hardness as specified.

The commercial defects or imperfections of mica are :—

1. Cross-grained or *'Jatai'*. 2. Wedge-mica breaks in films of uneven thickness. 3. Ruled mica. 4. Fancy triangle or zig-zag cuttings. 5. Clay or mud stains. 6. Air belts, bubbles or inclusions. 7. Mineral stains.

MICANITE INDUSTRY

First, blocks of mica 15′×6′ in size were obtained easily. As the electrical industry developed rapidly, it became difficult to get adequate supplies of large-size flawless mica to meet even a fraction of the ever-increasing requirements. The block mica has to be manufactured and must have the following properties :—

1. High dielectric strength and thermal and electric insulating properties and specific inductive capacity.
2. High heat resistance and relative infusibility.
3. Chemical stability and resistance to chemical effects.
4. Perfect cleavage parallel to one direction of plane.
5. Non-porous and impermeable to moisture.
6. Great flexibility and elasticity of laminae.
7. Transparency of various degrees, from clear to translucent.

This led to development of micanite or built-mica manufacturing industry. Hard sheet mica was getting scarce and is also subject to the following defects :—

1. It may have inclusions or defects. 2. Natural mica is limited both in dimensions and thickness. It could not be made to meet the required size and thickness quite accurately 3. Cost of flawless mica of large size is getting prohibitively high with plenty of supplies of small size mica.

In 1935, Mr. Franklin Brooks of the Mica Insulator Company of New York and Mr. S. H. Munsell of Munsell and Co., visited India and they were entertained by Mr. F. F. Chrestien at Tisri mica factory. They found enormous dumps of mica lying over the mining factory area, which could be made into splittings. Mica from No. 4 downwards were thrown away in dumps. Mr. Munsell trained a few boys and girls in splitting mica. Special splitting knives are used for the purpose.

Indian ruby mica splittings are found most suitable for the manufacture of best grade micanite for electrical purposes. Splittings are of different kinds :— 1. Book form. 2. Pan packed. 3. Loose or loose packed splittings including dust or power loose splittings. No. 4. and 6. book form splittings are used No. 6 is in large demand. For pan splittings, No. 3 and 6 splittings are used. Now loose packed-splittings are the cheapest and in great demand.

WORLD WAR II AND RESEARCH

World War II brought about an enormous demand for strategic mica and U. S. Govt. met the shortage by 1. improving economy in the use of available mica ; 2. procuring more mica from both domestic and foreign sources and 3. carrying on research into the basic problems of mica.

A great deal of research on mica generally was instituted in the U. S. A. during the War period by the National Research Council, National Bureau of Standards, etc. Such researches included investigations on testing, grading, classifying and quality control, mica substitutes, physical properties, splittings and punching etc.

The selection of mica adopted to particular applications was facilitated by the replacement under certain conditions of visual judgement by mechanical measurement. Evaluating quality of mica had previously been based largely on visual inspection., which afforded, at best, only an approximate index of the electrical mica. Considering properties under this method, considerable material had been discarded as unsuitable for more exacting uses.. The need for more precise methods of determining quality led to the development by the Bell Telephone Lab., of two instruments designed to eliminate the element of guess work inherent in visual appraisal, and so to reduce waste. They gave quick determination of power factor, dielectric strength, etc. The mica research programme was the intensified research for substitutes for mica accompanied by minor attempts to discover a method for producing it synthetically. Substitutes have been derived that could replace 10 to 15 percent of its strategic uses.

The bulk of the Indian exports of mica goes to U. K. and U. S. A. The splittings form an important portion of India's export trade. U. S. A. is India's largest customer for them. The export figures are given in the table below.

The Central Government is making an effort to organise the Indian mica industry on a more sound and profitable basis. The principal objectives, according to the Indian Mica Enquiry Committee's Report (1946) are : fairer prices for Indian exports of mica through scientific grading and marketing ; conservation of mica by compulsory use of proper mining methods ; greater use of the mineral in indigenous industries ; encouragement of the production of muscovite scrap, and ground mica.

The prices of Indian mica are affected by the unrestricted competition between traders exporting independently. The majority opinion in the trade favours some sort of organised trading | that will avoid these disadvantages. The Committee therefore suggested that a marketing control board, consisting of 3 Govt. representatives and 19 other members, be set up to prescribe standards and minimum prices, and to control the export of mica. The Govt. of India intends to impose a general levy or levies on mica produced or exported, the revenue being set aside as a fund for improving labour conditions in mica mines.

VALUE OF EXPORTS OF MICA FROM 1938-1947 (in Rupees)

Year	Block	Splittings	Waste	Total
1938	43,84.730	67,85,554	1,55,062	1,13,25,346
1939	67,74,641	84,79,960	1,81,424	1,54 36,025
1940	59,53,895	99,78,846	1,15,954	1,60,48,945
1941	86,22,227	1,79,25,763	12,868	2,65,60,808
1942	1,14,13,753	1,72,53,858	3,11,659	2.89,79,270
1943	1,42,47,761	1,54,87.403	92,453	2,98.27,619
1944	1,09,04,030	1,63,94.458	2,950	2,73,01,458
1945	1,52,02,674	92,60,911	13,727	2,44,77,312
1546	1,15,42,906	1,91.92,217	1.71,839	3,09,46,962
1947	1,17,90,819	3,46 77,842	1,20,502	4,65,89 163

MICA FROM MINE TO MARKET

BY

F. S. WATCHA

Mica occupies the same place in the mineral world as orchid occupies amongst flowers. As regards its size, colour and cleavage, very few minerals surpass it in attaining perfection.

Usable mica is a mineral of pegmatite dykes. All pegmatites are eccentric, unpredictable and discontinuous, and any hard and fast rule to govern their occurrences is liable to frequent drastic violation. As such any attempt to calculate possible reserve will be a mere guess work and of hypothetical nature.

Mica mines in India today are in one respect a good deal like people. Each mine is an individual ; each tends to be different from every other one and to get best out of itself, the mining engineer has to deal with each one with the same care as we have to use in dealing with human nature.

Mica was first an ***article of ornament*** used for glazed windows and for stoves. With the advent of electricity it became the ***useful mineral*** having triple property of resistance to heat, shock, and electricity. It became an ***essential mineral*** because of its use in condensers for radio and internal combustion engines and it is now a "***Strategic***" ***mineral*** because planes, tanks and submarines are useless without mica.

The Mica Indusry, to be perfect, should be par excellence in several phases, namely, mining, rifting and fabrication ; and grinding of scrap mica to meet the demand of the rubber, paint and plastic industries.

Indian Mica is known more for its foreign market than for its domestic use. We are sellers of mica, and if we are to maintain a receptive market of our commodity against Brazilian, Canadian and American mica we must learn to deliver our goods in conformity with the customer's demand. Following notes are just a guide to help in fixing such a set of specification that can be universally employed.

Mica is graded according to the size. To be of value for manufacture, mica books must be of such size as permits trimming to at least 1½" × 2" for sheet mica or 1½ square inch of clear area for punch mica for washers. All mica that will not split or rift to these minimum dimensions is termed ***scrap mica.***

Fig. 1 gives the chart for grading mica to India and A. S. T. M. size, whereas ***fig.2*** gives chart for grading mica for American domestic mica. Indian standard is more tolerant of length and provides for more elasticity of width and size when compared to American standard for their domestic use.

Although size can be measured by other means also, beyond experience of trained eyes, there is no other substitute guide for the measurement of quality and preparation.

The following factors can serve as a guide for judging quality and preparation.

1. *Colour* :—It is more valuable as a means of identification than as an indication of quality. It may be white, ruby or green.
2. *Thickness* :—Minimum should be ·007″.
3. *Spots and clay stains* :—None, light or heavy.
4. *Air pockets* :—None, few or many.
5. *Trimmings* :—Should be without cracks all round.
6. *Flatness* :—It is noted by reflection of a straight line on mica sheet and it is necessary to check every size of reflection, i. e. flat, curved or rippled.
7. *Splittings* :—To check any gumminess or cracking, i. e. good, medium and poor.
8. *Hardness* :—Hard, medium, soft.
9. *Grading* :—Small, medium, large.
10. *Other defects* :—Like cracks, hair lines or sandholes. They are difficult to see and must be watched carefully.

Mica Industry now faces competition regarding both sheet mica as well as scrap mica in our foreign captured market. Output of ground mica in U. S. A. is on increase. It is obtained there by mechanical methods which include processing of pegmatite minerals. Most of the ground mica is obtained from kaolinized pegmatite by crushing, grinding and washing. It is also obtained as a bye-product of felspar industry. Scrap mica is obtained as a bye-product from sheet mica and its trimming. There are mica grinding plants and one micronizer mill, supplying mica from 20 mesh down to micronised material, which finds its use for roofing wall papers, rubber, paint and plastics.

Bureau of Mines, U. S. A, have already made experiments for producing synthetic flourine-phlogopite mica and outstandingdevelopment of the plant has been the progress in producing sheet mica of bigger and bigger dimensions.

Factors which determine the course of market for mica are price, convenience in obtaining commodity and dependability. With expanding use of electricity in the world and with manufacturing of electrical machineries at high pitch, there are all possibilities of Indian mica holding its own against synthetic product for sometime. But to maintain this market co-ordinated selling is necessary for maintaining old customers and for securing new ones. For those who join the battle to maintain mica's market and its prestige, reward will be bountiful.

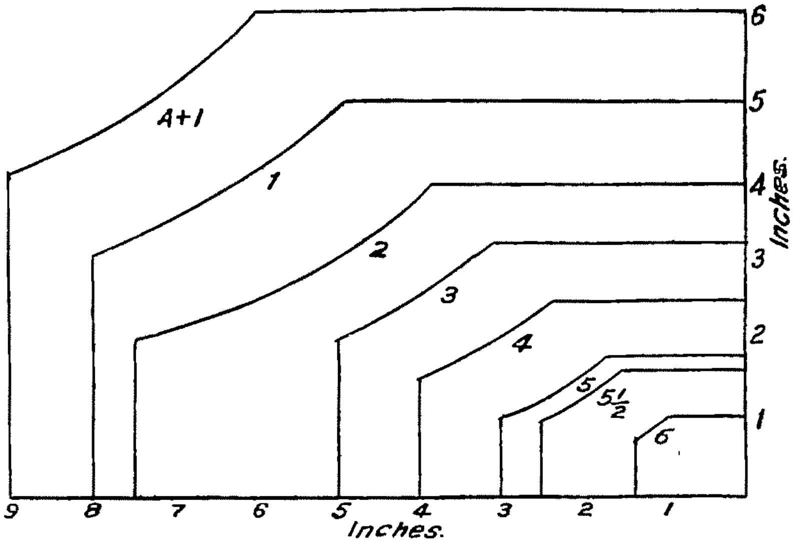


Fig. 1
CHART FOR GRADING MICA TO INDIA & ASTM SIZES.

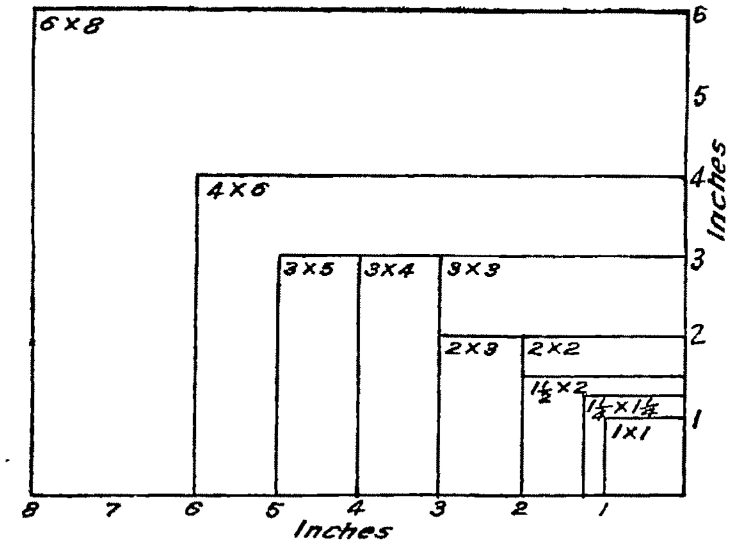


Fig. 2
CHART FOR GRADING AMERICAN DOMESTIC MICA.

SOME OUTSTANDING PROBLEMS OF THE MICA-PEGMATITES

BY

N. L. SHARMA

Pegmatites are regarded as the 'Museum of Nature'; and the dumps of debris at their workings are the favourite hunting ground of Mineralogists. This is mainly due to the large size of crystals, the great masses of single minerals and the host of rare minerals which are found in some of the pegmatites. Such minerals are found in no other veins or dykes and in no other associations. To give a few examples, single crystals of *spodumene* (Li-pyroxene) up to 47 ft. in length and 5 ft. in diameter and weighing 90 tons, have been found in the famous Etta pegmatite (S. Dakota, U.S.A.). In the pegmatites of the same region, other rare minerals like *amblygonite* (Li-phosphate) in masses measuring up to 27 ft. across, and *columbite tantalite* (niboate and tantalate of iron & manganese) in masses weighing up to 2,000 lbs., have been found. A single mass of *tantalite* which yielded 3 tons of ore was found in the Alto Taboo pegmatite in Brazil. A crystal of *beryl*, 18 ft. long and 4 ft. in diameter weighing 18 tons, was obtained from one of the pegmatites in Maine (U.S.A.). Still bigger crystals of beryl, 20 ft. long & 4 ft. in diameter weighing about 20 tons, are reported to have been found in the pegmatites at Bisundi in Ajmere-Merwara and Tiloli in Mewar. Single books of *muscovite* mica, weighing ¼ to ½ ton and measuring 3 to 4 ft. across, are found in many mica mines of Bihar. In eastern Transvaal, muscovite was found in the form of a broad bladed aggregate 12′ x 12′ x 8′. *Biotite* crystals which would yield clear squares with sides 12″ long, have been noted in a felspar mine in Rajputana. Crystals of *Tourmaline* up to 12′ in length and 18″ in diameter have been reported from the pegmatites in Mewar. *Garnet* crystals about a foot in diameter have been found in some pegmatites of Kodarma area. *Apatite* crystal, over a foot in length and 8″ in diameter, has been seen in a Rajputana pegmatite. Single *Felspar* crystals up to 33′ long have been reported from a pegmatite in Norway; and *Quartz* crystals weighing more than 1,000 lbs. each have been found in several pegmatites of various countries.

The specific gravities (according to Dana) of the minerals mentioned above, are given below:

Columbite-tantalite	5.3. to 7.3 (5.43 to 6.65 for Rajputana specimens)
Spodumene	3.13 to 3.20
Amblygonite	3.01 to 3.09
Beryl	2.63 to 2.80 (2.68-2.72 for Rajputana specimens)
Apatite	3.17 to 3.23
Garnet	3.15 to 4.3

Tourmaline	2.98 to 3.20
Biotite	2.7 to 3.1
Muscovite	2.76 to 3.0
Felspar	2.54 to 2.57 (microcline) 2.60 to 2.62 (albite)
Quartz	2.65 to 2.66

Felspar and quartz are the essential minerals of which these pegmatites are mainly composed of, and they are ordinarily the last minerals to crystallise from granitic magmas. Any theory put forward for the origin of such pegmatites should explain satisfactorily how the huge crystals and masses of the other minerals, some of them very heavy, which are rather accessory and first to crystallise, could develop, without any support and unattached at the ends, in a melt of the composition of the felspar and quartz, having the specific gravity up to 2.66. The presence of volatiles and water vapour in this melt is likely to lower the specific gravity of this melt further. The formation of such crystals can be well explained only if we assume that the hydrothermal solutions dissolve the older (pre-existing) minerals of the pegmatites and precipitate newer ones, thus giving rise to the commercially important pegmatites of 'complex type'. This is the view advocated by many American petrologists.

As early as 1939, the author (jointly with Dr. S. K. Roy and Shri G. C. Chatterji) discussed the problems of the mica-pegmatites of Kodarma and gave evidence in support of the 'replacement origin' of these pegmatites (*Geological Magazine*, Vol. 76, pp. 145-164, 1939). It was rather strange that amongst the list of 'recent publications' given at the end of the *Bulletin* on Mica by Dr. J. A. Dunn (*Rec. Geol. Surv. Ind.*, Vol. 76, *Bull. No.* 10, 1942), our paper mentioned above, did not find any mention. According to Dunn, the pegmatites are the products of 'simple gradual crystallisation, with normal attendant reactions, during a single prolonged period of moving solutions,' the distinct stages of replacement being not justified by evidence. Dr. Dunn regards the pegmatites to be formed from magmatic solutions which contained abundant volatile constituents (H_2O, Li, B, F, etc.) and carried a little potash felspar from the granite but they took soda-felspar from mica-schists and mica-gneisses (diabrochites).

In 1947, Dr. K. P. Rode (*Quart. Jour. Geol. Min. and Met. Soc. Ind., Vol.* 19 pp. 1-6, 1947) suggested that the mica in a pegmatite near Panchet hill has been formed by hydrothermal replacement of felspar, as the fully developed crystals of mica are found to be actually pseudomorphs after orthoclase in this locality.

No systematic work has been undertaken in India to study the paragenesis of the various minerals of the mica-pegmatites. Dr. H. Crookshank (*Trans. Min. Geol. Met. Inst. Ind. Vol, 42, pp.* 105-189, 1948) has, however, recently described in detail the minerals of the Rajputana pegmatites and their mutual relations. According to him, there were two phases in the development of the Rajputana pegmatites, the potassic and the sodic. In the first phase, quartz and microcline were intruded, and in the second, which doubtless followed rapidly the first, a much finer intergrowth of quartz and albite with a little microcline. Further, he thinks it possible that large beryl and microcline crystals were porphyritic crystals formed in deep-seated magma and carried into their present position by a magma composed mainly of silica and water. The small crystals of these minerals associated with a relatively fine-grained quartz-albite intergrowth, may have grown *'in situ'* from a cooling magma.

It is inconceivable, how 20′ long beryl crystals with which tantalite-columbite is also sometimes intergrown, were carried upwards in a melt of silica and water, and supported while the latter crystallised. Due to the extreme thinness of some of the pegmatite veins it is believed by many workers, that the pegmatite magma works its way through thin openings, even of capillary size. This view is further supported by the the common lenticular shape of the intrusions of pegmatites which are seen to pinch and swell out both in horizontal and vertical directions. Most of the pegmatites did not fill up the pre-existing fissures, some of which are to be postulated to be open and of such dimensions as to allow huge crystals of beryl and microcline to pass through easily.

It is interesting to note that Dr. Crookshank has described in beryl crystals, cores of quartz, felspar, tourmaline and mica, either alone or in combination, intergrowth of beryl with columbite-tantalite and an occurrence of vermicular beryl ramifying in all directions through a rather fine-grained pegmatite consisting of pink albite and quartz. To an ordinary petrologist such instances and similar other which one finds in going through the description of individual minerals in the paper give enough clue to the role, which replacement must have played in the formation of pegmatite minerals ; but Dr. Crookshank does not appear to assign much importance to replacement and explains such exceptional cases as due to corrosion or partial replacement of large and earlier-formed minerals of the first phase and the subsequent filling up of the cavity with the later minerals of the second phase.

When we come to the study of the views about the origin of the individual minerals of the pegmatites, we find that only a few of the minerals out of the lot found in pegmatites, are singled out and supposed by certain petrologists to be derived from, or by contamination of, the country rocks. Mica (both muscovite and biotite) is one, garnet and albite are others. The problem of the association of muscovite with pegmatites traversing micaceous schists and gneisses, has been dealt with in great detail by us in our paper published in the *Geological Magazine*, mentioned previously. Dr. Crookshank believes that much of the muscovite has been derived by absorption of the muscovite-schists, and biotite has been largely absorbed from the surrounding biotite-schists of the country rocks. However, it is interesting to note in his paper, that good muscovite-bearing pegmatites occur freely in hornblende-, or biotite-schists and they are also known amongst quartzites, but not yet found in limestones and granites.

Regarding garnet, Dr. Crookshank believes that though the mineral is developed for the most part in pegmatites which have absorbed the country rock, there is no doubt that much of it is derived direct from the magma. Further, he does not agree with Dr. Dunn's view that the albite of the pegmatites was derived from the country rocks. The author of this note has not seen this view regarding the origin of the albite of pegmatites, postulated by any other geologist than Dr. Dunn.

Dr. Crookshank's work in Rajputana at least supports the common view put forward by us for the Bihar pegmatites, that the residual pegmatitic magma of a granite splits into potash-rich and soda-rich fractions and the former intrudes earlier than the latter. Detailed work in studying the mutual relations of the minerals of the Bihar pegmatites is likely to yield valuable information to decide whether further differentiation of the residual magma did take place, resulting in the formation of hydrothermal solutions of different composition and the formation of the various minerals of pegmatites by the process of replacement through a long and continued flow of these solutions.

GEOLOGICAL MAPPING IN BIHAR MICA FIELD

(PART I)

BY

A. N. KALIA

The Mica belt of Bihar extends from the Gaya to the Monghyr District covering an area, approximately 100 miles long and 20 miles broad. The belt is running approximately E.N.E. and W.N.W. The country is mostly rugged and this applies particularly to the area in the Kodarma Reserve Forest. In other parts flat terrain with wide *nallas*, as in Ganwan State, is a topographical feature accentuated by deforestation and excessive weathering. The area is covered by sillimanite and mica-gneisses, mica-, and quartz-schists and calc-granulites, quartzites, amphibolites, with intrusions of dome gneisses, pegmatites, metadolerites and dolerites of ages varying from lower Dharwar to post Gondwana. The pegmatite veins are associated with both mica schists and gneisses, but those of the commercial value are invariably bounded by mica-schists. Although mica deposits are of vital importance, the field has not yet been satisfactorily mapped geologically. The work involved is, of course, of colossal nature particularly having regard to the difficult environments, deep forests, unsatisfactory transport conditions, and above all the surface soil, grass, forest vegetation covering to a large extent the rocks of the field. There are, furthermore, innumerable veins running through the mass of the country rock of varying thickness and lengths of which hardly about 1 to 2% are of commercial value. The veins are striking roughly south east and north west and dipping about north east, in the western part of the belt, but dipping about south or S W. in the eastern parts. Some veins also strike north and south, but their number is small and very often such veins dip due east in the western part and due west in the eastern part. The length by strike varies from a few feet to half-a-mile or more. Generally speaking, the middle eastern part of the belt, particularly in Ganwan State, very long strike met with and also some very massive and thick veins.

As regards the thickness, it varies from fraction of an inch to several feet easily 200 to 300 ft. or more. In the western part of the belt, particularly the Kodarma Reserve Forest, the country rock and the veins are very much disturbed and folded adding considerably to mining difficulties. Veins occurring in gneisses, however do not show much of folding or lenticular characteristics. Apart from the folding, pitching of the veins is very erratic giving the three dimensional complications of the mica veins. Generally speaking, the pitch of the majority of the deposits is to the east. The veins are lenticular in nature. Widening and thinning of lenses in narrow veins is not so much pronounced as in the massive veins particularly of the folded regions, where sometimes a vein as much as 50 ft. thick suddenly pinches to a stringer in the course of a few feet both laterally and in depth.

As regards dips, they vary from vertical to horizontal, but most of the veins dip within a range of about 45° to 70°. Furthermore, the dip changes in the same vein from place to place along the strike in various horizons and this causes changes in the direction of the strike in the same vein. The majority of the veins have the usual zonal characteristics with all or a few zones developed. Most of the deposits are symmetrically zoned but some are also asymmetrical. Some deposits are replacement deposits. Others segregation disseminated in the mass of pegmatite of usually granitic texture. The mica occurs in contact with the walls and on both sides of the quartz core. In the case of schist enclaves, which are often encountered particularly in the massive pegmatites, mica also occurs alongside these enclaves.

As regards the texture of the pegmatites met with, it varies from pegmatitic to graphic. In the veins dipping about north or NE the enrichment generally is on the hanging wall side, whereas in the south or SW dipping veins, the enrichment is on the foot wall. Very often both wall contacts are productive, although both wall contacts are seldom of the same richness. Sometimes when one wall contact is barren, mica occurs on the other wall contact. Mica concentration is of irregular character, but pay shoots are met with in some deposits rich in mica contents. Generally speaking, the rich parts are alternating with barren zones locally called '*char*' and as a rule, the bigger the richer part the bigger is the barren zone or '*char*'. More than one pay shoot are sometimes met with in the same vein. Mica concentration appears to become more pronounced where enclaves of schists are encountered in the pegmatites or where the dip suddenly flattens or in the limbs of the folds.

In very massive veins, sometimes lodes are running in the midst of the pegmatite mass following, of course, the general direction of the strike. In some veins the mica is far too small and scattered to warrant extraction. The quality and size of mica vary from vein to vein and in a particular vein the quality generally remains almost the same both laterally and in depth, and sometimes also the proportion of large and small size mica. Near the surface, however, due to weathering the quality of mica particularly of the splitting type gets deteriorated. The area of the belt, however, can be generally demarcated roughly into ruby mica producing areas and more or less white or stained, heavily stained splitting quality producing areas. Kodarma Reserve Forest produces on the whole good quality mica as distinct from Ganwan State, which dominates in splitting quality mica. Parts of the latter, however, in the northern side extending eastwards and westwards, contain good ruby quality mica, but the output is small.

Generally speaking, good quality mica is obtained from rather narrow or pipe veins containing low mica concentration, the massive rich deposits producing mostly splitting quality mica. Veins producing white, heavily stained, black-dotted or bottle green mica are generally rich in mica content. Different types of formation are met with being influenced somewhat by the type of country rock. These are tabular, branching, synclinal, anticlinal, trough-shaped, pipes, lenticular etc. The majority of the veins are concordant with the foliation of the country rock. Some are discordant and some partly concordant and partly discordant. In gneisses, the pegmatites appear to have filled fractures which generally transect foliation or beddings. The dips of such deposits are generally vertical or steeply inclined. Mixture of plagioclase and quartz, particulary smoky quartz, is generally a very good sign and accompanies richness of mica. Orthoclase is generally an unhealthy sign and means barrenness. Sometimes, however, in the midst of predominantly orthoclase pegmatite, mica lode is met with in association with small bits of quartz, very often smoky in nature. Sometimes in the same vein there are regions of orthoclase pegmatite and plagioclase pegmatite, the latter being productive. This may be the result of replacement. Quartz core is a healthy sign. When, however, in any vein the quartz core thickens it is generally at the expense of mica. Similarly whenever biotite is met with in any vein, muscovite is also produced along with it and if the proportion of biotite increases it is at the expense of muscovite. Tourmaline is generally found on the borders of the veins and it is generally associated with good quality mica. The richer the pegmatite the softer it is to break and frequently in a hard pegmatite when barren patches are met with the rock becomes harder. The veins pinch out to stringers which when followed sometimes lead to the continuation and/or opening up of further veins and this applies both to lateral extension and depth. The wall rock is also not of uniform thickness and very often in massive lenticular deposits when one of the walls thins out and vanishes, another lens opens out either in depth or along the strike. Sometimes only a comparatively thin mass of schist separates one lens of pegmatite from another. These characteristics and the behaviour of the wall rock result in opening out of several parallel veins or series of lenses situated in close proximity to each other and separated only by thick or thin intervening mass of country rock. All the foregoing is a matter of great geological interest requiring detailed geological mapping.

For the working of a deposit intelligently and to afford some scope for pre-planning, it is essential that all the geological features are studied and noted from time to time. In the first place, what is wanted is a Field Map to a say, 32″ to a mile scale showing the position of all veins, schists, gneisses, dykes, dome gneisses etc. by accurate surveying along with the position of *nallas*, contours etc. The areas of the belt other than the reserve forest should be demarcated into squares in continuation with the Reserve Forest Squares already marked out. Each mine should have a geological map both plan and section on a scale 20′ to an inch showing the position of the country rock in each level with dips etc. and showing richness of the vein and other interesting features like quartz core, occurrence of any rare minerals, texture and structure of the vein, presence of fissures, slickensides, faults, joints, rock foliations, folds etc. and this map should be correlated with the nearest square pillar. Furthermore, a geological map of an area say, within 500 to 800 ft. of the mine should be compiled, as a result of an accurate survey on a scale 50 to 60 ft. to an inch showing the outcrops of all veins, dips, 10 ft. interval contours, position of roads, *hallas*, foliation of the country rock etc. etc. and the underground position of the wall rocks, i. e. the shape of the pegmatite at each level. Several sections to give the correct picture of each pegmatite in relation to others in the neighbourhood should also be made, the contours at best be related to sea level datum.

All this work will lead to the proper and intelligent understanding of pegmatites, the mica reserves, and would possibly to the correct explanation of the origin of pegmatites and any laws relating to the zonal enrichment particularly when this is supplemented by examination of felspars taken from various regions of the pegmatite under the microscope for say the proportion of albite and anorthite etc. For actual mining operations, this would be of immense value. It will help in intelligent and correct prospecting which is so necessary either for locating parallel veins within easy working range or determining the continuity of the main vein when it gets disturbed or lost. The behaviour and continuity of payshoots or of the vein itself can be predicted with some measure of confidence and accuracy.

Not only is this important for ensuring intelligent exploration of the veins and payshoots, but also for the lay out of the shafts, haulage inclines, both on the surface and underground. These plans with suitable sections will give a three dimensional picture of the pegmatites and will yield very useful information which can be of help in dealing with all pegmatites of various forms. This will help in the correct correlation of one wall with the other, one deposit with the other and both walls in a single deposit and will result in several deposits in the neighbourhood of a mine being tackled from one mine with the resultant saving of mining costs which would be otherwise entailed if all these deposits or both walls and different payshoots in the same deposits are worked by several mines, as has been the case very often hitherto in the field. A good many shafts both incline and vertical are getting useless under present conditions due to the neglect of geological mapping, haulage and winding costs in the mines are rising resulting in the pre-mature closing down as the mines do not pay due to wasteful or involved methods of handling the waste rock. With labour cost rising, mechanisation is the only way for reducing mining costs, and thus geological mapping has an important bearing on the methods of working, layout of shafts etc. and exploratory work underground. Future mining must and will have to be one of methods of working where mechanisation can play a full part unlike the previous practice of restricting work to the so-called payable deposits or payable parts of the deposits so that all avoidable dead work can be prevented. Geological mapping on the above lines will, in a great measure, come to the rescue. The writer in the Part II has produced some plans and sections on the line referred to above describing geological feature of some of the pegmatites.

(PART II)

A part of Khalaktambi area in the Kodarma Reserve Forest comprising of parts of squares nos. 17 W and 1.7 and 16 W. and covering workings of Burria, Pesra No. 1 mine, Pesra No. 2 and Burria No. 2 mines and several other prospecting pits and outcrops in the neighbourhood has been geologically mapped and plotted on a scale 60' to an inch. Schist exposure, position of veins with wall rock, dips, position of roads, nalas, 10 feet interval contours reduced to sea level datum, position of the nearest square pillar, position of shafts and the underground position of walls enclosing the pegmatites have been shown. The position of walls underground have been shown in different colours to avoid any confusion that may arise due to overlapping and to help in obtaining an easy and correct idea of the shape of pegmatite in each level, its pitch and folding etc. Reduced heights of position of wall rocks at various depth horizons have also been shown in similar coloured ink. An attempt has been made to correlate accurately one pegmatite with another both on the surface and underground. Furthermore, plans of each level in respect of two of the largest and most important mines namely, Burria and Burria No. 2 have been separately prepared on the same scale in which the position of actual working and the wall rock have been shown. These plans also show the comparative productivity of the pegmatite in different regions in each level, the position of quartz core, some important characteristics of the pegmatite, barren zones etc. etc. These are also so made that they can be easily correlated with each other. Several sections have also been drawn both for Burria and Burria No. 2 pegmatite to give an idea of varying widths and average dips of the vein in different horizons. Productivity of the veins has also been indicated. The various sections are self explanatory.

BURRIA NO. 1 PEGMATITE

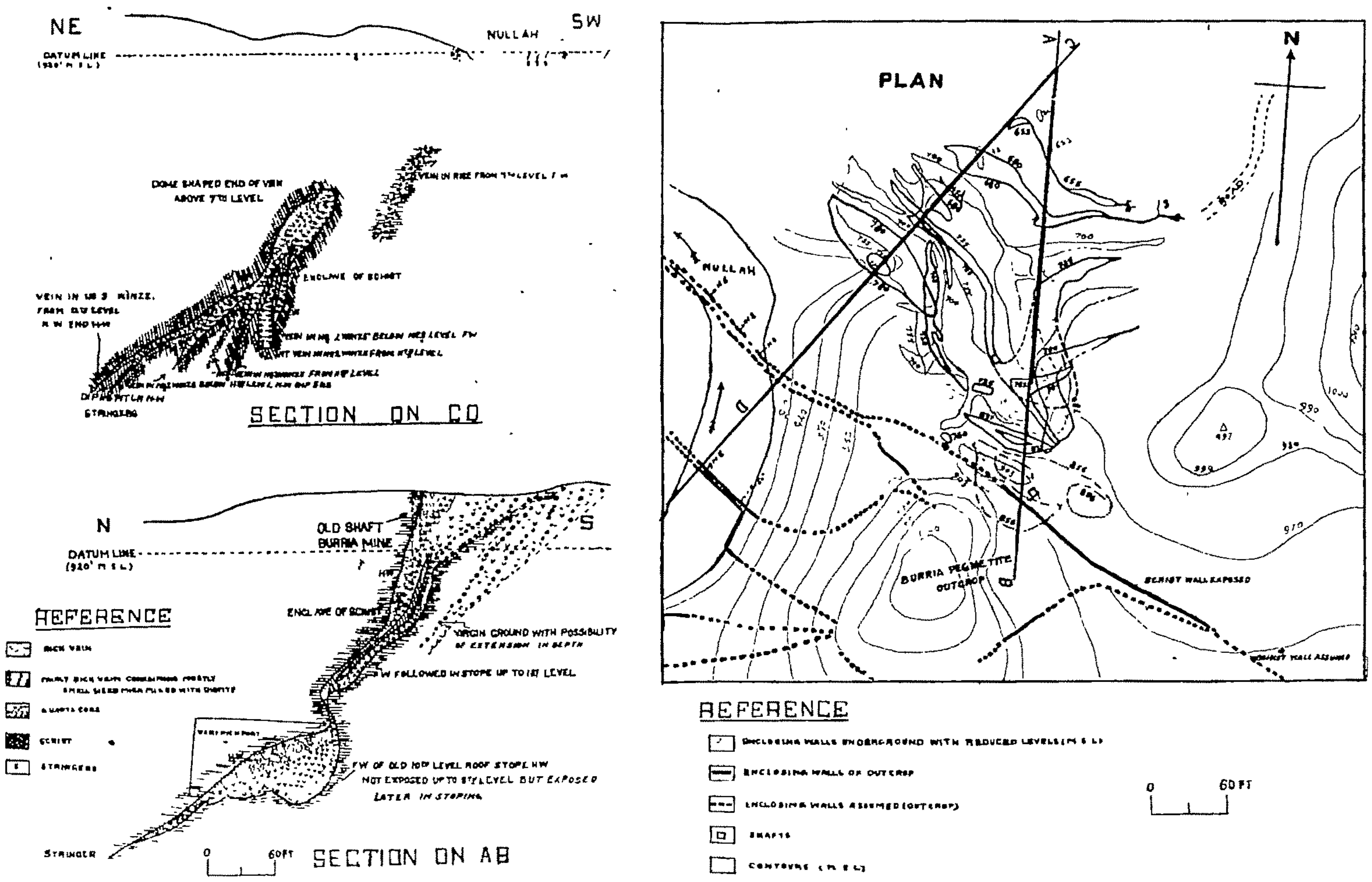
It is a very complicated pegmatite and will be evident from the various sections and the plans of the wall rocks. It is a massive pegmatite outcropping on a small hillock. The strike is partly North-West, South-East, and partly North-East, South-West and partly East and West, North-West and North, but generally North-West South-East. The length of the vein upto the 7th level is 80 to 100 ft. only but below the seventh level the length increases to over 300 ft. on the 8th level and then steadily decreases again until in the 12th it is a little over 100 ft. The maximum width of the pegmatite underground is about 60 feet and over the richest part it is about 30 feet. The width on the surface is easily over 100 feet. The maximum average breadth of the lode is about 4 to 6 feet increasing to 8 to 10 feet at places. The maximum width is 20 to 30 feet and this is between 9th and 10th level of the central part of the synclinal fold mentioned below. In many places the lode is only 2 to 3 feet wide, particularly from 1st to 7th level and about 1 foot to 1½ feet below the 10th level. The pegmatite has been developed by 13 levels upto a depth of nearly 380 feet from the surface. The average dip is about

60 degrees. The 1st, 2 nd, 3rd, 4th and 5th level were slightly to fairly productive mostly however, in the H.W. (wall) contact. In the 3rd level orthoclase preponderates and the vein was mostly barren. There is a mass of schist enclave dividing the vein into 2 parts, foot wall and hanging wall sections right from the 1st to the 6th levels. In the lower levels this schist has vanished and below the 7th level the vein has suddenly extended towards the north-west side. In the 8th level the strike becomes nearly 300 feet long as a result of the extension and the steady pitch of the vein towards about North-East, East. The richest part of the vein was in the south-east end on both sides of No. 2 haulage incline between the 9th and the 10th levels where maximum output of over 3700 maunds was obtained in one month during 1929 from stoping by hand drilling only and over 50% of mica was large in size. Below the 10th level, however, the vein became narrow with a width of only 1½ feet and ultimately vanished both in depth and laterally. The north-west end of the vein which developed below the 7th level was split up into two veins by the gradually widening of the mass of schist in depth. This schist made its first appearance on the 31st level horizon. The two veins each bounded by F. W. and H. W. were developed to the 13th level at first in fairly rich and productive ground and later in narrowing vein which diminished to 1′ in width and then pinched to stringers. The main vein on the H. W. side is also folded forming two flanks of synclinal formation with axis striking about N. E., S. W. In depth vein was thoroughly tested and left at places on stringers, The quality of the mica was very good ruby. In the F. W. section of the vein biotite including some very good splitting was also produced along with muscovite and generally F. W. side was poorer than the H. W. side.

With regard to the synclinal fold in the S. E. end the H. W. was sharply bending and becoming tapered towards S. E. end with its both sides behaving as H. W. for two limbs on the same vein. The F. W. however flattened out below the 10th level causing sudden thinning of vein from 40′ to 50′ width to about 1½ to 2′ width below the 10th level. The richest payshoot was in this bulge between 8th and 10th levels. Below the 10th level the vein all along the strike from N. W. to S. E. became very poor and steadily pinched to stringers in depth. These stringers persisted in the 13th level S. E. and also in two winzes below the 13th level H. W. In the latter their behaviour was peculiar. They would thin out to an inch or two and after an advance of 4 to 5 ft. would open to a foot wide through barren vein. As regards the second vein which opened below the 8th level due to the appearance of the intervening schist at that horizon the same was developed upto the 13th with fairly satisfactory results and output. This also produced some biotite. The width on the average was 1½ ft. to 2 ft. but at the N. W. end as will be evident from the drawing, it became over 15 ft. with two layers of schist 1 to 2 ft. thick running in the mass of pegmatite in the 10th level in a small pocket and the F. W. vein got connected with the main vein by the thinning and/or vanishing of dividing schist enclave mass referred to above at the N. W. end. In depth, however, the vein petered out to stringer and in one or two places as

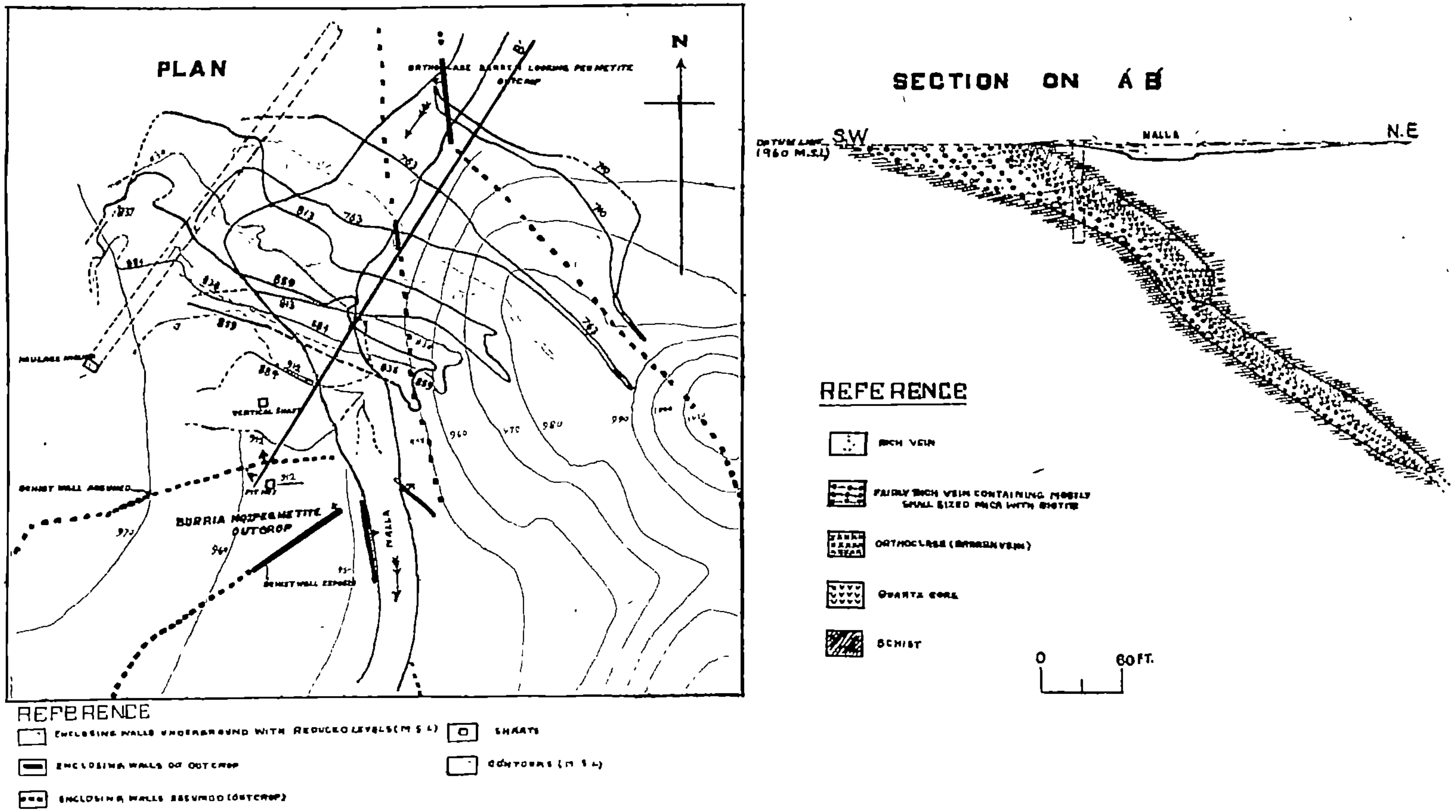
KHALAKTAMBI BURRIA MINE

Showing Pegmatite Enclosing Schist Walls in Surface and Underground.


NE
SW
NULLAH
DATUM LINE (920' M S L)
DOME SHAPED END OF VEIN ABOVE 7TH LEVEL
VEIN IN RISE FROM 7TH LEVEL F W
ENCLAVE OF SCHIST
VEIN IN NO 3 WINZE FROM 8TH LEVEL N W END HW
DIP OF PITCH HW
STRINGERS
SECTION ON CD
N
S
DATUM LINE (920' M S L)
OLD SHAFT BURRIA MINE
HW
ENCLAVE OF SCHIST
VIRGIN GROUND WITH POSSIBILITY OF EXTENSION IN DEPTH
HW FOLLOWED IN STOPE UP TO 1ST LEVEL
FW OF OLD 10TH LEVEL ROOF STOPE HW NOT EXPOSED UP TO 8TH LEVEL BUT EXPOSED LATER IN STOPING
STRINGER
0
60FT
SECTION ON AB
REFERENCE
RICH VEIN
FAIRLY RICH VEIN CONTAINING MOSTLY SMALL SIZED MICA MIXED WITH QUARTZ
QUARTZ CORE
SCHIST
STRINGERS
PLAN
N
NULLAH
A
B
C
D
BURRIA PEGMATITE OUTCROP
SCHIST WALL EXPOSED
SCHIST WALL ASSUMED
700
990
1000
970
REFERENCE
ENCLOSING WALLS UNDERGROUND WITH REDUCED LEVELS (M S L)
ENCLOSING WALLS OF OUTCROP
ENCLOSING WALLS ASSUMED (OUTCROP)
SHAFTS
CONTOURS (M S L)
0
60 FT

KHALAKTAMBI BURRIA No. 2 MINE

Showing Pegmatite Enclosing Schist Walls in Surface and Underground



shown stringer is still persisting. Other isolated lenses of the vein explored on the F. W. side as shown are more or less in the geometrical continuation of the strike but these also petered out both laterally and in depth to stringers. The peculiarity of the stringers in depth when they do persist is that when one stringer almost vanishes another thicker and more pronounced appears towards the H. W. and this goes deeper than the previous one. Another peculiarity noticed was for a stringer in at least two winzes on the F. W. side to open up into a lump of about 4'×3' pegmatite promising through almost barren, which also completely vanished after an advance of 2 or 3 ft. covering the face with a coarse grained schist without a trace of any stringer. When this end of the vein was stoped out from the bottom the vein became wider and wider and ultimately above the 8th (31st) level merged into the other on the H. W. with the thinning and ultimately vanishing of the intervening schist. Higher up the length of the strike diminised, the vein being confined to a short length at the North-West end only and vanishing into schist at the S. E. end, namely the schist separating the main lense at the S. E. end from the one at the N. W. end. This vein at the N. W. end assumed the form of a lense but a few feet above the 7th level this lense also suddenly vanished by the sudden closing in of the two bounding walls—F. W. suddenly sharply bending over to meet the H. W. forming a dome shaped end of the vein. Yet another pipe vein positioned far behind the strike of the above mentioned vein was revealed above the 7th level. This was pursued upwards but the vein gradually narrowed and produced mostly, 'Jetahi' biotite and pin-pitted mica. The mine was first opened probably in 1910, and preliminary stoping done above the 5th level by the old method of pillar splitting in 1918. Subsequent stoping along with development was started in 1929 and the mine finally gutted and closed down towards the end of 1941. As the names indicate 30, 31, 32 levels (7th, 8th and 9th) were developed in 1930, 31 and 1932 when the mine was also being stoped. Continuity of the vein at the N. W. end was established by the driving of intermediate level between the 8th and 9th although according to indications from 7th level which was all in schist, this was expected. This gave a fresh lease of life to the mine and resulted in the starting a new vertical winding shaft in May 1931. The shaft crossed the vein on the 8th level and then progressed into F. W. schist. The previous winding arrangement was by the old vertical shaft upto the 3rd level No. 1 haulage incline from 3rd to 7th following H. W. and again No. 2 haulage incline from 7th to 10th following H. W., i. e. in 3 stages. For at least a year or two before abandonment, the life of the mine, when all hope was lost, was extended by stoping of the F. W. contact of the vein in parts of 7th, 8th, 9th and 10th levels, at the S. E. end of the vein, as this wall was not all along exposed when the stoping of this section was carried out in 1929 and after.

BURRIA NO. 2—PEGMATITE.

This is so far a more straightforward pegmatite than Burria pegmatite and is situated about 500 ft. east of Burria pegmatite outcropping in the *nala* and on raised part of surface west of it. There used to be previously some *upperchella* pits which could not however be worked due to excessive water trouble resulting from the nearby *nala* and flooding during monsoons, After the vein was proved to be of payable character by the first level working from the vertical shaft, a concrete dam over 10 ft. high was constructed along the edge of the *nala* to enable uninterrupted work underground. The mine having been started about 9 years ago, the present workings have gone upto and a few feet below the 8th level. The pegmatite, as so far proved, appears to be massive. The east end of the vein has been reached in all the levels and the stringer in the 8th level east drive is still being followed with some hope for the future. The strike is roughly N. W.—S. E. and dip 45 degrees due North-East. The H. W. is very rich producing fair quantity of both large and small size mica. The F. W. contact is comparatively poorer yielding mostly small along with biotite. The length of the payshoot from the 1st to 7th level is about 250 ft. whereas in the t8h level it is only about 140 ft. Furthermore, the average width of the H. W. lode is about 5 ft. from 1st to 7th level in each wall-contact, whereas in the 8th it has become only about 3 to 4 ft. wide in between two walls and further down it has either pinched to a stringer or entered barren felspathic vein containing orthoclase. The vein is pitching east and this has rendered the haulage incline useless below the 7th level necessitating an auxiliary underground haulage incline from the 7th level downwards. The vein at the western end takes a sudden right-angled turn due south and the strike assumes the direction N. S. The vein at this end is massive with F. W. not properly traced upto the 5th level. In the 6th and 7th levels, however, the F. W. has been followed upto the haulage incline and then on the 7th level it takes a right-angled turn to south. Furthermore, this has started dipping due east and behaving as a H. W. In the first level east end an orthoclase vein lense gradually widening due east is encountered, and this is correlated with the surface outcrop of a massive barren orthoclase vein. Judging from mapping, extensive exploration further east is justified as also testing of narrow veins on the south of the main vein (shown in 1st level plan). Towards the west walls are not properly proved. The pegmatite is rich at the west end in biotite with a very small quantity of small sized muscovite. There are barren patches in the 2nd,3rd, 4th and 5th levels and when correlated they appear to be a part of the barren orthoclase vein shown in the 1st level east and mentioned above. It looks as if two veins of different strike directions have intersected each other and replacement has taken place. However, this seems a very interesting feature worthy of further investigation. The width of the vein is gradually increasing towards west. There is a quartz core 4 to 10 ft. thick running in the middle of the payshoot. Correlated with this vein is another barren orthoclase vein on the northern end, outcroping on the surface passing through the *nala* and striking N-S. This appears to dip west but has possibly taken a dip direction due east in depth. This vein appears to have joined with the orthoclase vein met with in the 1st level east drive by the thinning of the intervening schist in between due to different direction of the strike.

With a view to correlation all possible extensions of the outcrops have been traced—a task that is not easy in view of the dense forest growth, dumps and surface weathering concealing indications from sight. The actual exposures of schist walls have been marked in full lines whereas the expected continuity of these as suggested or supposed has been denoted by broken ones. All *upperchella* workings marked as U. T. pits within the survey boundaries have been plotted mentioning their approx. depths. These include workings on the Rani Hills, Pisra Gamaria, Konjia etc. Burria pegmatite sends off branches or offshoots along the extension of the strike at both ends. At the N-W end two are seen beautifully outcroping in the *nala* bed varying in width from 2 to 3 feet. The one on the H. W. side opens up further North-West to 8 ft. to 10 ft. wide barren orthoclase vein. That the vein underground does not extend so far N-W, may be either due to the vein pinching in depth or an enclave of schist (locally so called intrusive schist), cutting of its extension at that end. In the light of the surface features it is also reasonable to expect the extension of the veins above the 7th level where it becomes dome shaped and suddenly ends (see section on E. F.). Rise on the 7th level F. W. following a pipe vein mentioned above further lends support to this possibility.

As regards the offshoots on the S. E. end, they are only partly exposed—their continuity not being traceable. It is quite possible that a branch on the F. W. side shown crossing the *nala* and bifurcating further and containing *upperchella* pits forms an extension of this body. Indications in the 3rd level where crosscut into the F. W. has gone through veins though barren and its S-E extension on the F. W. in barren pegmatite tend to show that this may be the case. Burria No. 2 pegmatite containing though poorer quality mica than Burria pegmatite also appears to be correlated with this and seems to have started when or after Burria pegmatite has pinched at the eastern end. This is however, striking at this point in a different direction, i.e. north. The direction of the strike both of the main body of the Burria pegmatite and the main branches bears a close relation to the contour of the country being more or less parallel to them. As regards its underground run, it is more or less analogous to the course of the *nala* on the surface running on its south. Comparing the N-W section where there are two parallel veins below the 31st level with the S.E. a similar vein was to be expected from a geometrical point of view. The fact that all the S.E. levels from the 31st level down on the F.W. contact were covered by schist at the S. E. extension shows that it does not extend or if it does, the continuation has been cut off by an intrusion or barrier of schist. The possibility of the latter being the case is suggested by the presence of the pegmatite in the 3rd level behind the so called F.W. as exposed in the crosscut which can extend in depth.

As to Pesra No. 1 and No. 2 mines, these pegmatites are separated from each other by a barrier of schist. They get further and further apart due to the difference in their relative dips and the consequent widening of intervening schist barriers but nearly merge into each other on the surface on account of the widening of Pesra No. 1 pegmatite and flattening of its F.W. These are both in the nature of pipe veins. Pesra No. 1 at its S.E. end pinches to a stringer which further opens up into another massive outcrop which contains as shown two, 31 ft. deep *upperchella* pits on the H. W. connected with each other at the bottom. Behind the F.W. of this, another massive pegmatite outcrops which contains Pesra Gamaria mine nearly 80 ft. deep along with several other pits both on the H.W. and the F.W. of lesser depths. The sections on C.D., E.F., A.B., X.T.Y., T.U., show the features of Burria mine pegmatite whilst that on L.M. shows Pesra No. 1 and Pesra No. 2 inter-related. The section on C.D. shows the H.W. and the F.W. coming together above the 7th level when the vein becomes dome-shaped and ends. In between the two walls an enclave runs from 31st level downwards. Further down more schist enclaves are encountered splitting up the veins into further branches. The section shows how the vein has branched off into a number of stringers in depth. The rise on the 7th level is shown dotted behind the section. The section on E.F. shows the synclinal formation in between the 7th and 10th level and also the rise from the 7th level in relation to outcrop. The section on AB shows the vein explored in the deepest part. Virgin ground behind the 3rd level F.W. is also shown in relation to outcrop. The section on X.T.Y—T.U. two lines running across the average dip is an attempt to give a fair picture of the pegmatite in its entirety. Junction of two lines is marked by a break in the section. This shows the synclinal features mentioned above and the F.W. section showing the pinching of the veins to a stringer below the 12th level and the dome-shaped end of the vein above the 7th level; the section on L.M. shows the pegmatite of Pesra No. 1 and No. 2 mines with an intervening mass of schist. In the latter two veins with an intrusive schist in between have been shown according to the actual working. Both the veins were in barren zone and the latter also narrow when stoping was undertaken. The section of Burria No. 2 on A′B′ line shows the pitching of the veins due east and on C′ D′ the position of the haulage incline in relation to the vein.

With regard to the foliations of the country rock around Burria No. 1 & No. 2 mines, these appear to strike N-E and S-W and therefore both the pegmatites are slightly discordant. The enclosing wall rock of Burria No. 1 is garnetiferous mica schist whereas that of Burria No. 2 is biotite schist. Both are hard and compact in texture.

As regards water percolation, Burria No. 2 is very much more watery than Burria No. 1.

Only parts of plan showing Burria No. I and No. 2 pegmatites are being published by way of illustration. The larger plan and several other sections referred to were shown in the meeting held at Calcutta on 5-5-51.

MINING PROBLEMS IN BIHAR MICA FIELDS

BY

S. N. RAMNATHAN

INTRODUCTION

Mica has a large world demand due to its properties as an electrical insulator, making it a key commodity for the electric and electronics industries. India is reputed for its high quality sheet mica and mica splittings, and in recent years over 60% of the world's demands are met from this source. Next to coal, it is the largest mining industry in India and as much as 30,000 work-persons are engaged in direct mining operations in Bihar Mica Fields. Here, the mines are over 500 in number, both large and small, and are scattered over an area of over 1000 sq. miles in thick forests and rugged country, principally in the districts of Hazaribagh, Gaya and Monghyr.

Since the commencement of mining operations towards the end of last century, some progress has been made in the field of mining and in the efficiency of rifting and trimming processes of mine-run mica. But due to several reasons including peculiarity in its trade, the problems that are still encountered in the field are both numerous and fundamental. The current mining methods lay too much emphasis for production as against other national interests, and it is therefore time we give serious thought to some of the problems described below.

GEOLOGY AND PROSPECTING

Mica occurs as a constituent of pegmatite veins upto an average of 10%, which intrude the country rock (mica-schist) as lenses, sheets and dykes. It is in the shape of books of varying sizes and sometimes each book weighs several maunds. The associate minerals are quartz, felspar, tourmaline, garnet and apatite. Beryl and other rare minerals are sometimes found. Both, scientific bodies and a large number of geologists have already devoted much attention to the nature, form and origin of mica pegmatites and its constituent minerals. It may suffice to say here, that an adequate knowledge in geology of the distribution of mica with relation to the structural features of the deposit is a very essential factor for adopting efficient methods of mining. It has been observed that due to several reasons, all mica-pegmatites are not worth exploiting and the factors that chiefly determine are the size, quality and richness of recoverable sheet-mica. The veins have an erratic structure and mica concentrations are nowhere co-extensive with the deposit, thus complicating the problem of prospecting and mining. However, zonal distribution of mica in three or four structural forms of pegmatite is recognized by thumb rules in the field. Here again this zoning is three dimensional and this complicates mining to a further degree. Amongst the mines having large production are those with wall-zone and core-margin or intermediate deposits. The minerals in each zone are distinctly grouped into structural units of contrasting texture or composition.

At present, discoveries and prospecting termed as "*upperchella*" in the field, are made through chance, by gangs of unskilled workers who are usually paid by the produce they bring in from such work. Particularly in the rainy season, these men look for sign in the soil for mica books and dig pits following the vein from book to book to a maximum depth of 30 ft. The topography of the country is very helpful for such work and scattered pits are dug all over the area. No records are kept of these explorations and the money spent to gain such information is so small that subsequent mining ventures over these pits are often short-lived.

Even in underground operations, the geological problems are often complicated. For example in a wall-zone deposits, the productive ground is often lost by intervening layers of schist and other disturbances. In such cases diamond drilling in crosscuts may be of great assistance in locating the walls or limb of the dislocated vein.

Unlike other metalliferous mines, sampling may not be practicable in mica mines as a guide for exploration, but a careful study of the structure and rock alteration may apprise the ground in advance of working. In a wall-zone deposit, the presence of plagioclase felspar usually points out to a rich zone. Similarly in a core-margin deposit a biotite zone might assist in tracing the core margin that might have been missed.

A mine may easily be carried to disaster if the above factors are not borne in mind and this emphasises the need for the preparation and maintenance of suitable geological maps at least for each large mine in a field.

MINING METHODS

The pegmatite veins that are being worked in the field generally strike east-west and have a dip ranging between 30° to vertical. Their thickness varies from a few inches to several feet, according to the structural characteristics. The country rock mostly of schists, is generally hard and is not much traversed by faults. The workings are generally laid on that part of a vein where workable concentrations of mica occur. The mines that are being worked could be broadly brought under the following groups :—

(A). Prospectings or "*upperchella*" mines.
(B). Mines worked entirely by hand labour.
(C). Mines worked by mechanical power for pumping, hoisting and drilling.

The group 'A' has been described in the previous page. In group 'B', mines are generally worked with little capital from promising outcrops by a system of robbing the richer parts of the vein. Narrow and winding roadways are driven from the surface to a depth when difficulties in dealing with water and debris become unsurmountable. Occasionally an adit or a shaft is connected with the workings to serve as a second outlet. A windlass is often fitted in the shaft for dealing with the debris and water.

In group 'C', development work is progressed on a single vein by pushing drives, inclines or winzes forming intermediate blocks of ground, 20′ square and upwards, for support. In most mines, few productive places are kept open at one time with practically no exploration points. From the surface, shafts, adits and haulage inclines are placed as the circumstances warrant with little regard to the relative position of the vein and the reduced levels on the ground. The shafts are usually rectangular in shape, ranging from 7′×6′ to 10′×6′ for accommodating the hoisting compartment while the drives are usually 5′×6′ in size. The drives follow the rich zone and when some length of barren ground or disturbed area is passed through, cross-cuts are pushed rather desperately in an undermined direction. In several cases such honey-combed work have seriously weakened the stability of ground. Next, the workings are terminated both laterally and at depth when the vein pinches out or when it is necessary to penetrate through barren ground of such a size as to prove prohibitive.

At the next stage either underhand or overhand method of stoping is adopted along a straight face from the lowest point or on an intermediate block. The latter method is usually adopted from the back of a level as it facilitates filling the void left out. When the payable portion of block as observed, lies elsewhere on a block, that portion alone is stoped out in any convenient manner.

It would be desirable from the point of view of reserves and mine-economy to form larger blocks of ground, over 50′×50′ in the initial stage and while stoping, adopt the extraction in benches from a central winze or rise as the case may be. Also, in order to increase the productive period of a mine contiguous veins in the vicinity of the shaft, adits etc. should be tapped by useful exploration.

MINE SUPPORTS

Sal wood is usually used for all supports including shafts, drive sets and ladderways. The average life of this timber in a mine when conditions are not very humid is about 3 years. These sets are dressed at the spot from round timber and are fixed 3 to 10 ft. apart according to the nature of the ground. The sides are secured by laggings mostly of rejected sawn-timber. In soft or broken ground, the timber sets are subjected to heavy stresses particularly in the rainy season and as a result several collapses occur. It would be, therefore, advisable both in the interest of economy and safety, that masonry work be undertaken in such cases. Then the shafts could advantageously be made either oval or circular to suit conditions. It has been observed that in the preparation of erection of timber sets there is much waste of material and labour. The practice should therefore be to standardize timbering methods so that the sets could be readily made at convenient centres. The treatment of mine timber by various compounds available in the market deserves attention as these can prolong the life of timber to an equal period. Steel supports have still found little use in mines due to their non-availability and cost.

DRILLING, BLASTING AND HOISTING

The drilling of shot holes is done either by hand or by hammer drills weighing 40 to 60 lbs. and operated by compressed air. Stoper and drifter machines have not yet been introduced in the field. The machine crew consists of sets of three or four workmen, and holes are drilled at the faces haphazardly and not in accordance with any standard round. In a shift, a crew drills holes to a depth 60′ at an average of 12 ft. per hour and the depth of holes seldom exceeds 2 ft. When blasted, sockets are usually left behind as the placing of holes does not bear proper relation to the burden and the free face. This is clear, from records available at a group of mines where the explosive-costs per cu. yd. both in drives and stopes have no appreciable difference. If desired, jack hammer drill with a pully block contrivance and a hole director may be adopted in drilling a proper round of holes in a drive as on Rand. The drilling jumpers consist of haxagonal steel rod 7/8 inch in diameter generally of two or three sizes upto 5 feet long. Shanking and sharpening are usually done by hand and at some mines by machines. Often the labour is not very skilled and holes are commenced and finished off with a single jumper. Due to rapid loss of gauge and wear of cutting edge, drilling takes longer time. Wet drills are being gradually adopted to allay the dust injuries to drillers and as the humidity is low, this has no adverse effect on ventilation. Recently tungsten-carbide drill bits have been tried in a mine and apart from other advantages, the drilling speed was nearly doubled with no appreciable loss of gauge and wear of cutting edge. Proper laying of air-lines from the compressor to the work points even in large mines is sadly neglected and the leaks and losses in pressure are quite appreciable. Also due to lack of proper choice of machines, difficulties are often caused in maintaining the drills in constant use.

The rock encountered in mines is medium to hard and the explosive ammon-gelignite containing over 30% nitro-glycerine is used and is quite ample. Holes are blasted by fuse firing. Even in a small mine working a single relay shots anything over 50 is normal. The stemming material consists largely of debris, packed in leaves and this leaves much room for better blasting. As a guide, records of development if maintained can result in greater blasting efficiency.

In mechanised mines, "muck" from the face is removed and transported by hand labour in pans to the lowest or intermediate haulage point wherefrom it is raised in drums or buckets. Usually a steam or compressed air is placed either underground or on the surface to deal with the material. The present method often involves too many muckers and much labour can be eliminated by running down the debris through chutes to one or two concentrated points where from these can be easily handled by the hoists. Also rapid muck removal from the working face will facilitate the drilling of deeper round of holes.

DRAINAGE AND VENTILATION

The percolation of water in mica mine is usually small and in mechanised mines drainage does not present a major problem. Reciprocating pumps driven either by steam or compressed air are largely used. The barren winzes are used as water sumps and when necessary two or three stages are arranged. Often, the winzes and drives are continuously wet and by offsetting the winzes and pushing the drives on a gradient of at least 1 in 100 much of the water would drain itself to the sumps. The advantages of electricity for pumping and mine lighting have lately engaged the attention of mine managements.

The ventilation in all the mines is by natural means. It is generally coursed through the ends of workings and an adequate quantity of air is available underground in most of the months in the year. But during the monsoon there is general sluggishness as can be expected and in cases where the mine openings are almost on the same level, it tends to worsen. Also smoke due to blastings, causes discomfort at the working places but where available compressed air readily comes to the aid. There is, however, scope for the use of auxiliary fans or venturi blowers particularly when long exploratory drives are to be undertaken.

MINE PLANS AND MODELS ETC

The plan and section maintained at the mines show the bare requirements demanded by law and are on a scale varying between 16′ to an inch to 50′ to an inch. Neither the contours nor other natural features are indicated and this handicaps in planning the proper location of shafts, adits and cross-cuts. In order to identify veins and in estimating reserves in a mine, the need for mine models and hypothetical vein-sections may, before long, become necessary.

LABOUR AND ORGANISATION

The cost of labour nearly accounts for two-thirds of the cost of mining by underground methods. Work-persons for mines are recruited by *sirdars* either locally or from the adjoining districts. The local labour perhaps due to less rigour of employment in prospecting or *"upperchella"* work show less inclination to work in organised mines, inspite of the increased wages guaranteed by the recent award.

Further, most of the unskilled labour resident in mine camps do not as a rule work for a spell longer than two to three months. Although some time is lost in illness during the malarial season, the managements have not taken sufficient care for their well-being in providing proper housing, water facilities and medicines. The supervising staff are no doubt enthusiastic but there is lack of proper technical knowledge and ability to deal both with the men and machinery. Much overlapping of operations could be seen in several mines that are being worked in three relays due to poor organisation. Mechanised mining calls for considerable skill and if placed under proper organisation will pay suitable dividends. It is unfortunate that very few mining engineers are employed in the field for devoting their attention to these technical sides of things. Lastly, it must be emphasised to the management that mutual understanding of discipline which is at present lacking between workmen and officials should be developed for successfully operating the mines.

MINING COSTS

In the mica field the cost per maund of mine-run (KKA) or processed mica seemed to be the only criterion for a successful mine. The factors that affect this are large in number viz. labour, explosives, supplies including timber, power including compressed air and supervision. This figure varies anything upto Rs. 100 per maund of mine-run mica. In a large number of mines this cost is reckoned on a daily basis and naturally some of the above items are ignored. Sometimes, this encourages pilferring the reserves in a mine to a dangerous extent. However, costs calculation along proper lines on a monthly basis will be more realistic of the conditions obtained in the mine.

CONCLUSION

It is seen that mining problems are confronted with many difficulties and apparent among them is the absence of a positive long term policy. In the past, actual mining difficulties were few and simple due to prolific production in the extensive virgin field at shallow depths. But now mines are pushing to a depth of 1000 ft. and the picture is getting reversed. Mining operations are largely directed by the owners and their associates and among these some are so complacent as to reveal an attitude of mind which in effect says "There is little a mining engineer can do". To those it should be brought to light in all humility that the future of mica mining will be one of methods and economy and not on the chance discovery of rich pockets of mica. It is also to be borne in mind that as a result of scientific researches in U. S. A., the possibilities of commercial production of both synthetic and integrated mica replacing the natural product have been brought nearer and this may cause in future years some detriment to our industry. But I do hope, that with greater economy and efficiency in our methods of production and honest trade, we may be able to maintain the monopoly we have enjoyed for years. I have to remind, lastly, men in my profession that healthy rivalry in technical matters should be encouraged between various concerns and it will be seldom long before a good idea developed in a mine is tried out at other as an example.

MICA MINING—SOME PRACTICAL SUGGESTIONS

BY

HARIKANT MISHRA

To make any substantial comments on mica mining which may appeal to qualified technicians, is a matter of audacity on my part as I feel; but I hope you will allow me the privilege of expressing the views in the light of my experience that I have so far been able to gather having got the opportunity of working in the mica mines for about 11 years.

Mica is a dollar-earning industry, which indirectly helps future industrial developments of our present-day India. In Bihar, mica mining dates back more than 70 years. From the very beginning this industry had to face several difficulties. It is indeed a pity that, though Bihar Mica holds an economic position among the best of world's strategic materials, this industry is generally unknown to the Industrialists of India. Next to coal, this industry holds an important position. There has been no effort to provide a home market for Indian Mica. It can safely be said that the foreigners, who had practically no interest in our future development, left us quite in the dark about the uses of one of the most important mineral of our country. We are now free and in free India, every one of us should think in terms of utilising our natural resources, to the best possible advantage. It is surprising to note that mica which is an essential material for electrical industry is being used mostly in foreign countries. Big hydro electric projects which our Government have taken up, we expect, will be completed within a very short time; then we should be able to use mica in our country.

At present there are about 600 mica mines in the Bihar Mica Belt. Almost all the mines are under 'Managers', who are men of the field having sufficient practical experience. There is a school of thought, which is of opinion that systematic and scientific mining of this mineral can be done only by technically qualified mining engineers. But mica mining, taking into consideration, the erratic nature of the vein needs people of practical experience with the simplest form of science and art of mining. There is a great financial risk in mica mining. As you know there are different scientific methods by which prospecting of minerals other than mica can be or is being done, but for mica, there is no known method of discovering a vein or of being able to follow it with any degree of certainty. The present mica mines which are being operated are the results of a thorough and continuous prospecting by the local labourers generally known as Ghatwars and Bhullas. The role that highly qualified technical engineers can play is, in my opinion, extremely limited at present. A considerable amount of practical experience unlike any other mining is needed for following the mica vein scrupulously. At present in all the technical institutions in India, full training in this particular branch of mining is ignored. Mining engineers, if fully trained in mica mining, will pick up the art and science, that are required for the economic developments of mica deposits in a year or even less, while it will take much longer time for a man without technical education.

These days, the following categories of competent men are being employed to supervise the underground work in a mica mine :

(a) Mica Managers,
(b) Shift-Incharges,
(c) Sirdars and
(d) Shot-firers.

Almost all of them are men who have practical experience in the field itself. Their academic qualifications generally vary from Upper Standard to Matriculation. Mine Managers start their early careers as Shift Bosses and within 5 to 10 years, after learning the mining techniques, are promoted by their employers to be Mine Managers. Mica vein, as I have said, varies from mine to mine and from rock to rock. It does not follow any hard and fast rule, hence the men who actually study the particular vein, proves more useful for the development of that mine.

The mica mines are now going deeper and deeper. With the increase of depth the mining problem is also increased. By problem I mean that uptil now the number of small mines is far larger than that of the big mines, the proportion being 80% to 20% approximately. All the big mines are more or less mechanised and are being worked by Companies with bigger capitals. The main stumbling block in the way of mica mining is the debris or mucks which, if not tackled scientifically, eat up the vein as well as the capital.

In previous days, the wages of the labourers were ranging from -/1/6 to -/4/- per day and the mica was also practically on the surface. Now that even a small mine is below 50 ft. in depth and that the rate of a labourer including all other emoluments goes upto ten times, it has become impossible if not absurd, to work by crude methods. Mining, to compete in the present world, will have to be done on a scientific basis, otherwise the future of mica mining is dark. In order to study the above problem and apply scientific mining, the present day mica mine-managers with their practical experience, if trained in some institute on a particular line, would prove, a boon to the industry. Here it would not be out of place to mention that our present Inspector of Mines, Mr. S. N. Ramanathan, being guided by national interest, has very kindly started training these present Mica Mine Managers by delivering lectures in Hindi language on the different methods of metal mining in important mica mining centres. This has helped the mine managers and thereby the employers to a great extent. Mica Enquiry Committee had perhaps suggested for starting 'Evening Mining Classes' ; but this proposal has not yet materialised. In the interest of the Industry and the thirty thousand mica mine labourers, I would request our National Government to start 'Evening Mining Classes, in different mica mining centres of Bihar mica belt, so that the supe - vising staff may be trained scientifically to meet the present demand of the Industry.

Regarding Labour it may be said that at present mica mines are being guided by an 'Award' given by the Industrial Tribunal, Dhanbad, in the year 1948. The principal motive of the award was to improve the labour condition and to guard against absenteeism of the mica labourers, which has been a bane to the proper working of the mine. But this had little effect to check even a sirdar or a shot-firer who is entrusted with a very responsible job. Their increased wages have benefited the local liquor shops more than the labourers themselves. Hence it is of utmost importance that facilities should be provided to educate them by opening night schools so that they may realise what is best for them.

MICA MINING

BY

B. A. JANI

About 70 years ago, a white shining mineral attracted the attention in India of a white man called Mr. F. F. Chrestien, who penetrated into the thick forest of Hazaribagh District. This white mineral was mica, the shortage of which handicapped the development of electric industry for want of proper insulation. In fact the development of one industry depended on that of another. Mica having basal cleavage enabled it to be readily split into very thin sheets of thickness of even ½ mm. i. e. 2000 parts of an inch. It has various other qualities, making it specially fit for electrical industries, such as heat resisting qualities, infusibility, transparancy, imperviousness to water. It has wide use in equipments of war, equipments for planes and ships etc. It is essential for radio condensers, commutator, v-rings, segments for generators and motor armatures, aeroplane motor spark plugs, radio tubes and transformers. It is chemically stable, it has high di-electrical strength and can stand vibrations. It is unaffected by changes of temperature. Its splittings as films, when fixed together by some binding material yields big sheets or plates of any desired thickness, shape and size. This product known as micanite is useful also as an insulator. It is said that one of the causes of the defeat of Germany in the world war was shortage of this essential mineral.

KINDS OF MICA

Of the different kinds of mica (1) Muscovite, (2) Biotite and (3) Phlogopite are commercially important. Phlogopite is softer than muscovite. Chemically muscovite is silicate of potash and alumina, but phlogopite contains magnesia. Biotite is iron magnesium mica. India contributes 70% of world production of muscovite mica. Chief sources are Bihar, Madras and Rajputana. Bihar mica belt is the oldest and the most important. It runs through the Hazaribagh, Gaya, Monghyr and Bhagalpur Districts, and comprises an area of about 90 by 20 i. e. 1800 sq. miles. The best ruby mica (muscovite) best suited for electrical purposes, comes mostly from Bihar. Madras mica, mostly from Nellore, is green coloured and fetches less commercial value. There is also ruby mica (muscovite) there, but less in quantity. In Rajputana, mica (muscovite) from Mewar, Jaipur, Shahpura, is ruby tinted, but is buckled and hence fetches less price than that of Bihar ruby mica.

OCCURRENCE OF MICA

Mica is found in veins associated with pegmatite rock bounded by schist wall or walls, called foot wall and hanging wall. The vein may be continuous or scattered or in pockets or in break, sometimes productive, less productive, barren and again productive. The Pegmatite vein may disappear and encounter schist, but again after few feet advance through the schist, it may become a productive vein again.

MINING

So it means that mica mining consists of breaking ground which may be done firstly by hand labourers, compressed air, dry and wet drilling, preferably by wet drilling to guard against miner's diseases. Secondly *placing of holes*, explosives used, mis-fires are to be taken into consideration. Thirdly, it consists of timbering, involving a choice of timbers to be used. Fourthly comes *cleaning* and *raising debris* by tramlines, windlass, hoisting engines, ropes, fixing of ropes, capping detached hooks, buckets, skips, signals, pulley-wheels and headgears. Fifth is *drainage* involving the prevention of incoming water, putting of drainage channels, tunnels and adits ; use of pumps either by hand, steam or compressed air, Location of pumps, choice of their dimension and capacity. Next comes *Geology* of the veins involving a knowledge of outcrop, strike, dip, foldings, faulting, pitching etc. ; the nature of the country rock of metamorphic rocks, pegmatites, schist, and their mineralogy. *Surveying* follows. Accurate plans and sections made by qualified surveyor must be made. This is most important when an old mine or a near area is mined. The question of *Ventilation* is very essential then, as otherwise foul gases like carbon-dioxide and monoxide are likely to occur due to burning of candles, lamps etc., resulting in suffocation and death of labourers. This can be overcome by two methods viz. natural ventilation and artificial ventilation. Electric light is preferable to burning candles and lamps for light. Care should be also taken for making proper arrangement for urinary and excretion purposes. Lastly 9th item the welfare measures come in the picture, including the First Aid Box, arrangements for recreation for the labourers after the day's work. It should be borne in mind that labourers have to be well housed and kept cleaned, if proper work is wanted. I am glad to say that Govt. has taken notice of this aspect and has appointed labour welfare inspector, mobile shop, cinema, medical hospital in mining area. Though these are not adequate still a beginning at least has thus been done.

Mica raised from the mine in crude form is called book mica. This may vary in size from a few cubic inches to big book. This book is rifted into small slabs ready for sickle and knife dressing called Z. D. B. ; knife dressing is necessary to avoid more wastage. This Z. D. B. is mixed in sizes and qualities. It is sent to different skilled sorters to determine the grade such as No. 7, 6, 5, 4, 3, 2, 1, special, extra special etc., and qualities such as clear, clear S. S., fair stained, tiger stained, bear stained, heavily stained, densely stained, black spotted, black dotted, pin pitted etc. Clear and big size hard mica is sometimes sold at Rs. 3000/- per maund. After sorting, the mica goes in three forms, block mica, chillas and wastage. Block mica—is splitted in films called Fakni measuring not more than one and quarter millimeter in thickness. These are done mostly by women and children in factory and at home. Even in splitting there is grading called 1st loose, 2nd loose and 3rd etc. The last grade is mostly in the mines' dump or factory dump of waste mica at mines and factories.

CONCLUSION

Though India is a large producer of mica, unfortunately its use is mostly done by foreign countries. Inspite of this, the mica dealers' position is better due to high prices. This has made some owners to adopt some short policy to get rich quickly. If this policy is not changed, this industry will meet the same fate as coal, where some firms practised destructive methods, resulting in the abandonment of large area due to fires and subsidence. To avoid this fate in mica, upperchalla as surface scratching must not be left to unskilled labourer supervised by unskilled men. Of course prospecting or upperchalla in its true and scientific way is the fore-runners of subsequent mining. This being the case, all upperchalla work should be in the hands of competent persons guided by qualified engineer. This upperchalla is the great source of mica piracy about which much discussion has taken place, but it seems yet uncertain who is responsible for this and why so many legislations and acts have not been able to stop and eliminate it. f all mica miners and dealers resolve not to buy stolen mica, it will go a great way in lessening and preventing thieving.

If the industry is to survive, the following measures must be taken into consideration :

(1) Nationalisation of Mica Industry.

(2) Brick or masonry work to avoid huge consumption of timbers, thus protecting forest devastation.

(3) Sub-letting mica area and employment of contractors and sub-contractors for raising mica must be stopped.

(4) Employment of qualified mining engineers and assistants without let or hindrance in his work with full facilities to perform his duty must be adopted and encouraged.

(5) Posting of more mining inspectors in mining area, which is too large for one inspector.

(6) Strict adherance to mining rules and regulations.

(7) Good roads are also necessary for transportation.

(8) Discrimination in issuing mica mining and dealers licence to deserving persons ; last but not the least the sharing of prosperity of trade in proper proportion by the workers employed.

PRACTICAL HINTS ABOUT THE INSTALLATION AND MAINTENANCE OF AIR COMPRESSORS SUITABLE FOR MICA MINES

BY

B. BHADURY

Compressed air is now universally used by almost all the key industries of the world and it is second only to electricity in the extent and diversity of its application. It is an important factor in practically every phase of the art of manufacture. The rapid development of compressed air tools has brought about economical results that are reflected in every field of industry.

Many types of compressors have been developed to meet the multiple applications of compressed air and I shall deal here, in a non-technical language only with those compressors that are suitable for the Mica Mines, so that most of you engaged in the mines will be able to follow. It will be a good deal of satisfaction to me if the life of at least 5% of the compressors used in the mica mines are enhanced by their proper installation and maintenance.

The compressor is a machine, fitted with a piston intake at a pressure of 14.7 lbs. per sq. inch at sea level, and discharge valves, which, after sucking of the air from the atmosphere by the piston, through the intake valve, forces it into a smaller space than it originally occupied and this operation of forcing the air into a smaller space is called compression of the air.

In order to obtain an idea of the subject of air compression, there are certain underlying principles and laws that should be understood.

When the space occupied by a given volume of air is changed, both its pressure and temperature are changed in accordance with the (1) Boyle's and the (2) Charle's Laws.

According to Boyle's Law, if air is compressed in front of the piston, forced from one end towards the other, the pressure exerted by the air will increase in ratio as the volume is reduced (assuming constant temperature). That is, if the volume is reduced by half, the pressure is doubled.

According to the Charle's Law—at constant pressure, the volume of a gas is proportional to its absolute temperature ; at constant volume the pressure is proportional to its absolute temperature.

When air is compressed, heat is generated. This is the big problem in the design of compressors to get rid of the heat. In an ideal air compressor, the whole of the heat generated during compression would be carried away by the cooling water circulating through the water jackets, and whilst this is impossible in practice it is nevertheless essential to ensure that cooling is as efficient as possible.

The subject of heat of air compression has probably received more consideration in air compressor design than any other. It is to be noted that the heat generated during the compression results in a loss, because of the extra work which must be expended to overcome the excess pressure due to rise of temperature.

It must be evident from the foregoing explanations that isothermal compression i e. compression which takes place at constant temperature is the most economical. However, this method is impossible in practice, but an approach to it is obtained by compression in stages and cooling the air between each stage.

Modern compressors may be classified as follows into :—

1. (a) Single Stage—Single Acting. (b) Single Stage—Double Acting.

2. Multi Stage—from 2 to 4 stages.

A single stage compressor is one in which the compression takes place in a single cylinder. In a single acting compressor, the compression takes place in every other stroke and in a double acting compressor the compression occurs in every stroke.

A two-stage compressor is one in which air is compressed to a certain pressure in a low pressure cylinder and is then discharged into an inter-cooler, which reduces the temperature. This low pressure, after cooling through the inter-cooler, is then admitted into a high pressure cylinder—compressed and discharged at high pressure.

Single stage compressors are suitable for a pressure range from 80 to 100 lbs. gauge. Two stage compressors are used for pressure from 80 to 500 lbs. Three stage from 500 to 1500 lbs. and four stage compressors are used for pressures above 1500 lbs.

The advantages of two stage compressors are as follows :—

The final temperature of the air is reduced, horse power required to drive the compressor is reduced, entrained moisture in the air is practically reduced, volumetric efficiency is increased, and lastly it reduces maximum piston loads below those, which would be found in a single stage compressor with equal displacement.

If air be compressed in a single cylinder, for atmosphere, at a temparature of 60°F to a final pressure of 100 lbs., the maximum temperature will be 484°F. This temperature is destructive to common lubricants and ordinary oils are burned into a solid gritty coke-like substance, unless proper cooling devices are employed to keep the parts cold. This carbon deposit collecting in parts and valves may so obstruct and clog them as to cause leakage and throw an additional load on the compressor.

If, however, the same volume of air be compressed in the low pressure cylinder to a pressure of 25 lbs., the highest temperature which can be reached is only 233°F, a heat which will not leave a deposit or destroy the lubricating qualities of good oils such as should be used in air compressors work.

In multi-stage compressors, therefore, the conditions of temperature are seen to be most conducive to thorough lubrication of the pistons and valves tending towards durability and tightness of the working parts with sustained efficiency of the machine.

The effect of altitude on air compression is an important factor which should be considered at the time of selecting a compressor. The pressure of the air in the atmosphere, drawn by the piston of a compressor through the air filter, is taken ordinarily at 14.7 lbs. per sq. in. at sea level. For a rough calculation, it may be assumed that the pressure decreases ½ lb. per sq. inch for every 1000 ft. of ascent.

If a compressor be operated at a greater altitude than sea level (14.7 lbs. per sq. inch) the admission air pressure will be proportionately less and additional work is imposed upon the compressor.

It is, therefore, evident that the capacity of a compressor is less at higher altitudes than at sea level because of the diminished density of air being admitted and the horse power required under such conditions being less. It should be understood that for equal capacity more horse power is required for altitude compression than at sea level.

Then the selection of a compressor should be made very carefully after taking into consideration the following factors :—

1. Type of compressor, (2) Actual capacity in cu. ft. of free air per minute and the gauge pressure to which it is to be compressed. (3) Type of drive, i.e. direct coupled, plain or v-belts etc. (4) To be driven from, i,e. electric motor, steam, line shafting, oil or petrol engine. In the case of electric motors or engines their speed and rated B. H. P. should be mentioned. For existing line shafting its speed should be given and any limitations as regards pulley sizes that can be fitted, stated. If the compressor is to be supplied with prime mover in the case of electric motor and steam drive, characteristics of electric supply or steam supply available should be specified. (5) Where site conditions give temperatures and altitudes higher than those normally recorded in the country, where the compressor is manufactured full particulars should be given. (6) While selecting a compressor, provision should be made for a reserve capacity of the compressor, as it is experienced that compressed air installations almost invariably grow ; it is therefore generally a wise and economical precaution in the first place to instal a compressor larger than what is needed for immediate requirements.

The installation of a compressor should be carried out by an expert. There are many important factors to be taken into consideration at the time of the installation and if the job is left with a novice the life of the compressor is bound to be shortened.

For a big mica mine which has gone down below 500 ft., it is a wrong practice to instal a big compressor on the surface. The long length of pipes with their numerous bends and elbows not only strangle the compressors, but the efficiency of the compressors is also reduced by 30 to 40%. Besides this, the leakage in the air lines in a big mine should also be taken into consideration. In some of the big mines, the air pressure received at the Jack hammers is not more than 30 to 50 lbs. only.

For big mines it is a better proposition to generate electricity on the surface and to instal portable compressors driven by electric motors near the actual working faces. This system will altogether eliminate frictional losses in the pipes. There will be no leakage of air and the question of moisture and oil, which is a bugbear in long pipe lines, will be entirely eliminated and hence the life of the pneumatic tools will be increased.

At the time of installing a compressor, the following important points should be remembered :—

The inlet pipe (suction pipe) of an air compressor should be kept above the ground level. The inlet pipe, should be so located that steam, water, dust or other waste, being discharged from pipes near it, cannot be blown or drawn into the compressor inlet pipes. Provision should be made for a filter if the intake air contains any dust or other abrasive material. Such materials if carried into the cylinder will cause rapid wear of the piston and cylinder and will promote the formation of carbon on the valves. If for some reason it is not possible to fit an air filter the inlet pipe should be run some 8 to 10 ft. above the ground. The size of the inlet connection on the compressor cylinder is indicated on the foundation plan. The inlet pipe should be atleast this size and it is a good rule to increase it one pipe size for every 10 ft. in length. The inlet pipe to compressor should be thoroughly cleaned before the machine is first put in operation to remove accumulations of pipe scales, sand, grit or other foreign objects thoughtlessly placed in the pipe during the work of installing the compressor.

The discharge pipe connects the discharge opening of the compressor cylinder with the After-Cooler and Receiver. Its size must be at least as large as the connection on the cylinder. It should be short and direct and have as few elbows as possible and where the latter are necessary, they should be long radius elbows. In case of overhead piping, it must be well-supported, so that there is no strain on the compressor cylinder.

An air receiver of ample capacity is a sound investment. The use of compressed air is rarely constant and the larger the receiver the better will be the compressor to cope with any sudden and large demand on the air supply.

The air-receiver should be placed as close to the compressor (or after-cooler, if one is fitted) as possible in order to keep the discharge pipe short. No valve should be placed in the line between the compressor and receiver, unless a safety valve is installed between this valve and the compressor, as there is a possibility of starting the compressor with this valve closed. In such a case an explosion will result, as the air cannot escape. When the compressor is to be connected into an air main, in common with another compressor, a safety valve should be placed between the compressor and the first valve in the pipe line. This will safeguard the compressor in case of failure to open the valve before starting up. If the compressor is placed near the wall of the building the receiver should be placed outside the building where it has an opportunity to radiate some of the heat. A drain cock is placed near the bottom of the receiver which should be drained several times a day.

Water-cooled compressors are provided with inlet, outlet and drain openings in the water jacket. The controlling valve should be placed on the water inlet. The hot water from the outlet should fall into an open pipe end or funnel, so that it can be seen at a glance whether water is passing through the jacket.

Rapid circulation of the water is as important in a compressor water-jacket as in a boiler, and for this reason a water circulating pump should be installed in all cases where water tanks are employed for cooling purposes. A little extra care in ensuring rapid circulation of cool water through the compressor jackets is amply repaid by the saving made in horse power taken by the machine.

In petrol and diesel engines, thermo-syphon circulation system is, in many cases, sufficient, because the real function of the cooling water is only to keep the metal of the engine cylinder at temperatures which will allow of efficient lubrication. The thermo-syphon system is not suitable for air compressor work owing to slow circulation.

Tank cooling cannot be generally recommended for two-stage compressors with inter-cooler or where an after-cooler is installed. The efficiency of a two-stage compressor is based on a constant heat extraction in the inter-cooler, which in turn entirely depends on a constant low inlet water temperature to the inter-cooler. As such conditions are not normally practicable with tanks, where water from mains or some source ensuring constant low temperature is not available, it is desirable to instal a cooling tower or some similar means of maintaining a supply of cooling water at constant inlet temperature.

As a general rule, the difference in temperature at the cylinder inlet and outlet should not exceed 10°F. The approximate size of tank and amount of water required can be calculated as follows :—

For circulating water from main, allow one gallon of water per minute for every 100 cu. ft. of free air delivered per minute for single-stage compressor and 2¼ gallons for two-stage compressor with inter-cooler.

The capacity of tank required is given as follows :—Allow about 1¼ gallon for every cu. ft. of free air delivered per minute for normal working conditions. If the compressor is allowed to run on two shifts, the capacity of the tank should be doubled.

For the main air lines, i.e. from the air receiver to the bottom of the shaft, it is essential that the pipes should be of such diameter as to avoid excessive frictional losses. Moreover it is my experience that compressed air installations almost invariably grow and for this reason it is generally a wise and economical precaution in the first place to put in a pipe larger than what is needed for immediate requirements.

Where possible, the pipes should be laid above ground, so that they may be inspected and any joint leakages promptly detected and repaired.

It is practically impossible to avoid a small amount of moisture in the air passing from the receiver to the air main and this on further cooling condenses out and is deposited in the pipe. For this reason, where practicable the main run of piping should be given a slight fall back to the air receiver and branch lines laid out from the upper side of the main run. Vertical pipes should have a drain cock fitted at the lowest point.

The pipe-line should be inspected over its whole length at regular intervals—the more frequently the better—as small leaks, unobservable except under close inspection, result in serious losses in volume and pressure of air.

The pipe-lines for compressed air in mica mines are generally laid out without proper planning and supervision resulting in serious air leakage and it is certain that if only half as much care were taken to make and maintain effective joints, and to minimise leakage, as is taken in the case of electrical transmission line, a very decided gain in efficiency would inevitably result.

SILICOSIS & PNEUMOKONIOSES

BY

G. S. MARWAHA

In the course of discussion in the symposium of Mica, mention has several times been made of silicosis. From the various remarks made, it appears that most of the members have, at best, a very hazy idea about this industrial disease which vitally affects the health of workers in all the mineral industries. The following note gives the latest information in a concise form on the medical aspects of this subject,

Silicosis is the name of a specific lung-disease included in the more comprehensive term "pneumokonioses" used to denote lung-diseases caused by inhalation of dusts of various kinds. "Silicosis" results from the inhalation. of silica dust, "asbestosis" from asbestos, "siderosis" from iron, while the disease in coal miners is known as the "pneumokoniosis of coal workers". The information supplied below refers to pneumokoniosis in general i.e. all lung diseases resulting from inhalation of dusts.

1. CAUSE : Dust particles are invariably present in all air inhaled, but the human body is provided with several natural mechanisms to prevent this inhaled dust from causing damage to the lungs. These include nasal filtration, movement and secretion of bronchial tubes, and the action of the cells which line the air sacs. These latter have the property of becoming scavenger cells. Pneumokoniosis may arise whenever these scavenger cells get affected by the nature of the particles taken up or whenever the amount of dust to be dealt with overwhelms the natural defences. It is now accepted that only fine particles of a size 5 microns or under can reach the air sacs.

2. METHODS OF ACTION OF DUST : The natural reaction to the presence of a foreign substance lying free in the tissues is the development of a fibrous tissue-capsule to wall it off. The fibrous tissues so formed partially occlude the mouths of the air sacs. Air can still be forced into the affected air sacs but cannot be forced out, and in course of time the walls of the affected sacs are stretched to such an extent that they finally rupture giving rise to the condition known as 'emphysema'.

3. EFFECTS OF DIFFERENT TYPES OF DUSTS : The precise pathological change produced by the dust as it occupies the lungs depends upon the constitution of the dust. It is believed that the behaviour of a scavenger cell is influenced by the solubility of the particles it engulfs. Silica (especially in the form of freshly fractured quartz) is relatively soluble, and stimulates the appetite of the cells, while decreasing their mobility so that they die and disintegrate before they have time to reach the natural filters ; and so their load of dust-particles comes to lie free in the framework of the lungs. A similar state

of affairs follows the inhalation of a high concentration of relatively inert dust (other than silica dust) of a size 5 microns or less, not because of the effect on the scavenger cells, but because the natural defences are overwhelmed by the shear weight of numbers. Thus we may distinguish between a specific type of pneumókoniosis, namely 'silicosis' due to silica, and a non-specific type due to a mixture of different substances containing much less free silica.

This actual method of action of different dusts, however, has not been finally agreed to. It may be said, nevertheless, that whilst silicosis may well arise as a consequence of a chemical or physio-chemical reaction between the lung-tissue and the silica dust, the non-specific disease is more readily explicable as the result of simple overloading of lungs with dust irrespective of its nature. In these latter cases, it appears that as more dust is deposited than can be removed, it collects into small aggregates which then undergoes a very mild form of fibrosis thereby preventing further disposal of the dust and resulting in the development of 'focal emphysema'.

4. DEVELOPMENT OF THE DISEASE : In the case of silica, the fibrous tissue reaction is out of all proportion to the amount of dust present, and its formation goes on long after the exposure to silica dust has ceased. In the case of coal dust, however, the reaction is just sufficient to wall off the deposit of particles and it ceases when there is no further exposure to dust. It cannot, however, be reversed.

5. FORMS OF THE DISEASE : Pneumokoniosis may be simple or infected. In a typical case of 'simple' pneumokoniosis, the disease is distributed more or less uniformly throughout the substance of both lungs. On the other hand, the lungs may have certain totally affected areas with a background of simple pneumokoniosis. Such an area takes the form of a hard rubbery mass that might be homogeneous or might have a central cavity filled with a fluid. The bursting of this fluid into a bronchus gives rise to "black pit". It is now accepted that the main factor responsible for this change from the simple form of the disease is infection. This form is, therefore, called "infected" pneumokoniosis. This infection is believed to be tuberculosis though not necessarily in an active form.

6. SYMPTOMS OF THE DISEASE :
(a) Simple Pneumokoniosis.—The main symptom in early stages is breathlessness (Reticulation) followed by tightness of the chest and cough, though the latter may not always be present. The patient may be quite fit in other respects ; and if he be removed from the dust-concentration—or alternatively, if allowed to work under "improved" conditions (which have, by now, been defined)—the disease will not get worse. As already mentioned, it will not, however, get any better whether work is resumed or not.

After reaching a certain stage of development, the disease progresses steadily whether the patient is taken away from the dust or continues to be exposed to it, and ultimately results in death at a time depending upon the age at which he contracted the disease. In fact, once this stage has been reached, nothing can stop its progression which although slow is very definite ; and removal to dust-free atmosphere and rest etc. do not have any bearing on this progression. In such advanced stages, the breathlessness may become so acute that the patient might have to take a breath between each two words spoken, and a talk of 50 to 100 words might easily take 10 to 40 minutes. In many cases, the general health of these men may be good.

(b) Infected Pneumokoniosis.—Once the disease becomes infected, the patient becomes more prone to lung-complications such as tuberculosis, bronchitasis, pneumonia etc., in which case damage to one or both lungs may be very rapid with fatal results.

7. FACTORS INFLUENCING PRODUCTION OF DISEASE : It is obvious that for a dust to produce disease, a sufficient amount must collect in the lungs producing what is known as "the effective occupation" of the lungs by dust. The extent of this accumulation depends upon :

(i) Size of dust particles—As already mentioned, only fine particles of less than 5 micron size can effectively participate in the production of this disease.

(ii) Concentration of air-borne dust—Depending on the type of dust, the minimum concentration necessary to initiate the disease varies from 450 to 1050 particles of $\frac{1}{2}$-5 micron size per c. c. of air.

(iii) Duration of exposure.—This varies with the other factors enumerated.

(iv) Depth of breathing due to physical exertion.—This has a very doubtful effect.

(v) Individual susceptibility to the accumulation of dust in the lungs.—The efficiency of the pulmonary mechanisms for eliminating inhaled particulated matter seems to vary widely from one individual to another.

At the risk of repetition, one thing in this connection must be made very clear. Because of the irreversible nature of the lung-changes, medical treatment cannot return the lung to complete normality. Prevention, therefore, is the only cure. The basic requirement for the prevention of the disease is the suppression of dust (preferably at its source) combined with adequate ventilation. Once initiated, the only means of arresting simple pneumokoniosis is removal from the dust-

SYNTHETIC MICA

BY

D. B. SAHANA

The chemical properties of Muscovite mica have been described by Dr. J. A. Dunn in his book (No. 10—Mica, Records of the Geological Survey of India, Volume LXXVI—page 4) as given below :—

		Bihar Ruby	Madras	Canadian Phlogopite
“ SiO_2	....	45·57	46.28	39·66
Al_2O_3	....	36·72	36·02	17·00
Fe_2O_3	...	0·95	0·32	0·27
FeO	...	1·28	1·58	0·20
MgO	...	0·38	0·84	26·49
CaO	....	0·21	1·32	...
Na_2O	...	0 62	0·82	0·60
K_2O	...	8·81	9·10	9·97
Li_2O	....	0·89	...	...
H_2O	....	5·05	3·32	2 99
F	...	0·19	trace	2·24
TiO_2	...	...	...	0·56
BaO	...	....	...	0·62
Total	...	99.93	99.60	100·60 ”

We have learnt on good authority that research work in the U. S. A. and in Europe has resulted in the successful invention of synthetic mica. This is certainly a disquieting piece of news for the Indian Mica Industry. No one can be stopped from carrying on scientific investigation and research. There are some people who think that the news of invention of synthetic mica is just an international hoax. But we must not be lulled into a sense of false security. Scientists in Europe and in America have been working to find out a substitute for mica since World War No. 1. I am quoting below some extracts on the subject which are self-explanatory.

1. Extract from the October 1946 issue of the **Harper's Magazine**

> "Mica was another thing. None is mined in Germany, so during the war our Signal Corps was mystified. Where was Germany getting it ? One day a certian piece of mica was handed to one of our experts in U. S. Bureau of Mines for analysis and opinion. "Natural Mica", he reported, "and no impurities". But the mica was synthetic. The Kaiser Wilhelm Institute for Silicate Research had discovered how to make it and—something which had always eluded scientists—in large sheets.
>
> We know now, thanks to Fiat teams, that ingredients of natural mica were melted in crucibles of carbon capable of taking 2,350 degrees of heat, and then,

this the real secret, cooled in a special way. Complete absence of vibration was the first essential. Then two forces directly perpendicular to each other were applied. One, vertically, was a controlled gradient of temperature in the cooling. At right angles to this horizontally, was introduced a magnetic field. This forced the formation of the crystals in large laminated sheets on that plane".

2. Taken from The New York Times of August 1st 1948 :—

"Work on strategic substance now is in pilot-plant stage.

A research program undertaken several years ago to develop the production of synthetic mica in commercial quantities and make the United States independent of foreign sources of this strategic mineral has reached the pilot-plant stage, the Army and Navy announced yesterday.

The synthetic mica has all the characteristics of natural mica that is used widely in electronic equipment as an insulating material and for resistors, the office of Naval research, The Army Signal Corps and the Navy Bureau of Ships reported.

The success of the research program also raises the possibility that mica parts may be fabricated directly from the synthetic product without the time-consuming and laborious tasks of sorting, grading, splitting and trimming necessary with natural mica.

The natural substance is a translucent silicate mineral with unique electrical properties that make it particularly suited for use in radio, radar, television and other circuits. It is split easily into thin sheets and can be shaped as desired. It is not affected easily by chemical corrosive agents.

Mica is mined extensively in India and Brazil. In spite of Government subsidy of $ 6 a pound, fields in this country were able to supply only 15% of the amount needed in the critical war years of 1943 and 1944, the announcement said. Commercial production of the synthetic product can fill this country's needs and make it unnecessary to stock-pile for future emergencies.

U. S. RESERCH BEGAN IN 1946

The synthetic is of a type known as fluorine-phlogopite mica. Patents on mica substitute have been granted from time to time during the last thirty years, but none of them have resulted in the preparation of crystals large enough to be used in place of the natural mineral. Government sponsored research began with a Signal Corps contrast at the Colorado School of Mines of June 15, 1946. The Bureau of Mines Electrotechnical Laboratory began pilot-plant work on September 1, 1947, under a contract with office of Naval Research.

The Owners-Corning-Fiberglass Corporation has been retained under a consulting contract to make available all data and patents acquired by that company and the Corning Glass Works during investigation of mica synthesis in 1945 and 1946, the announcement said. Other groups also participated in the work.

The present Army-Navy research project is expected to solve the engineering problems involved in the synthesis of mica on an industrial scale and to define the conditions under which the manufacture of mica may be feasible economically.

Organisations interested in the possible application of fluorine-phlogopite mica were invited to communicate with the office of Naval Research for further details".

3. Quoted from NOTES ON MICA by J. Coggin Brown, p. 16 :—

MICA SUBSTITUTES—Various substitutes for mica have been placed on the market from time to time and were especially developed in Germany during the war. The more important of them are listed below, and it will be seen that they are mainly compressed paper products impregnated with the so-called artificial resins, condensation products of phenol and formaldehyde. None of these substitutes seriously threaten the natural mica market.

'Pertinax', is a compressed paper product which was developed in Germany during the war and used especially for high-tension condensers.

'Bakelite' is a synthetic product made from phenol and formaldehyde.

'Paxolin' is made entirely of paper impregnated with varnish, the chief constituent of which is a condensation product of phenol and formaldehyde.

'Formalite' is a similar composition.

'Leatheroid' is a fibrous material produced from cellulose."

4. Quoted from the report of the Mica Enquiry Committee 1944-45,

(PAGE 99)

"Two materials which have been much advertised as Mica substitutes—Alsifilm (or Diaples) and Polectron (or Lectrofilm)—have also entered the field."

5. Quoted from September 1948 issue of the Mineral India, Page 17 :—

"MICA POWDER FILM"—"According to Dr. Lal C. Verman, who recently returned from a visit to Europe and the U. S. A. a Swiss technologist has fabricated the "Mica Powder". When commercially available, this mica substitute, it is said, can successfully compete with natural mica in the manufacture of electrical tape."

6. Quotation from the United States Tariff Commission Report No. 130.

During a supplemental field trip in June 1938, it was learned that the Massachusetts Institute of Technology had, on or about June 9, 1938, announced the discovery and patenting of a method for making inorganic films closely resembling mica in their important electrical and physical properties. It was learned that an arrangement had been made by the Institute whereby the Research Corporation is to undertake commercial development and control of the patented process in co-operation with the inventor. Some of the details of this process were described to the Tariff Commission's representative by the Boston agent of the Research Corporation, and it was deemed to be of such importance that this survey of the mica industry, which was practically ready to go to the press, was delayed until an authorized statement concerning the process was prepared by the inventor, Dr. E. A. Hauser, and the Boston representative of the Research Corporation, Mr. Carrol Wilson, and released to the Tariff Commission. This statement follows :

As a result of recent work which has been carried on by Dr. Ernst A. Hauser and his associates at the Massachusetts Institute of Technology, certain new types of inorganic films have been made and studies of the properties of these films indicate that they may be suitable as a substitute for natural mica in certain applications. Moreover, in view of their low cost of manufacture and their properties of resistance to acids, alkalis, and oils, and ability to withstand red heat without loss of strength it is believed that these films may find useful applications in many fields.

It has been found that when certain highly hydrated colloidal clays, such, for example, as bentonite, are suspended in water and substantially monodisperse fractions of the colloidal clay particles are separated out, the gels of these fractions form upon drying coherent, self-supporting flexible films. No binder is necessary. When these films are heated under pressure their strength and transparency are greatly increased and their electrical resistance is comparable with that of mica. Although relatively polydisperse fractions will form films, those made from substantially monodisperse fractions are of superior quality. The monodisperse fractions may be obtained by allowing the particles to form in various layers according to size by gravity settling in solution or preferably by separation in a supercentrifuge.

Such films, when made from bentonite (hydrated aluminium or magnesium silicates) are very similar in chemical composition to mica and when dried to a low water content they exhibit many of the same properties. Films of different thickness may be made depending upon the thickness of the original layer of gel. Similarly, a laminated product may be made up from a number of thin sheets.

An intensive research program is being carried on to develop more information regarding these films and their characteristics under a variety of conditions and in order to develop more fully the theory of their formation. Careful consideration is being given to the suitability of variously treated films as substitutes for natural mica in condensers, radio tubes, and other applications. As these studies progress they will be reported from time to time in the scientific and technical literature.

This statement embodies all the information now available (July 1938) for publication. Except as stated above, nothing is known concerning the cost of producing the synthetic product. It should be noted, however, that the Research Corporation, under whose auspices the commercial exploitation of the process will be undertaken, is a concern whose equipment, organization, and experience are peculiarly well adapted to the task. It is an engineering foundation organized for profit, but its character provides that it may not pay dividends but must devote all profits to scientific research. Its 25-year record of accomplishments along these lines has been a successful one, notably the development of the Cottrell electric precipitation patents, certain regional rights to which constituted its founding assets.

If synthetic mica becomes a commercial and technical success it will seriously modify the conditions outlined in this report with respect to sources and control of supply, tariff problems and the long established organization of the industry as a whole. Colloidal clays are inexpensive and fairly widely distributed and the quantity required for synthetic sheet mica production is relatively insignificant. The process would yield films of thicker sheets as desired, technically perfect in physical structure, and with controlled chemical analyses, in particular, the possible substitution of synthetic sheets for the built-up mica now universally used in electrical designs, appears to be the most significant economic aspect of the synthetic development.

7. Quotation from New York Times, 11th June, 1950.

NEW INTEGRATED MICA WILL ASSURE SUPPLY OF PRIME DEFENCE MATERIALS—Strides are being made in solving the national defence problem of finding adequate sources of mica, needed for electrical parts in military and industrial equipment. First reports have been received of the "Mica Symposium" held on May 8 at the Navy Department in Washington through co-operation of the National Security Industrial Association, 110 William Street. It is disclosed that a pilot plant for making a new material called "integrated mica" is now nearly complete, after ten years of research.

At the symposium, technician displayed the 'largest sheet of natural mica ever made." It was described as "a piece nine inches wide and nine feet long". The substance is pure mica, made entirely from mica scrap which exists in profusion in this country.

This was one of ten specific representations at the symposium. Cobines, the topics dealt with included new substitutes for mica in capacitors, improvements in glass dielectrics, substitutes for mica in electronic tubes, substitutes for natural black steatite talc, and best methods foı determining qualities of these materials.

SECRET DATA 'DECLASSIFIED'

Delays in disclosing much of these data occurred because information presented at the meeting included secret data, some of which has now been 'declassified' for use. Members of technical panels asked that names of companies and technical experts be withheld in the news.

The new material, which promises to make America self-sufficient to a large degree for some grades of mica, has approximately the same electrical characteristics as natural mica. When impregnated with small quantities of resins the material is strong and water resistant. Its resistance to heat is better than that of natural mica, since it does not 'puff up'.

Describing the qualities of new substitute, a research spokesman told the National Security Conference group 'integrated mica should entirely replace the material that is now made fıom India splitting'. It will replace block mica to the extent of about 80 per cent of its present usage, he continued.

Integrated mica can be made cheaply enough to compete with the better classes of paper now used in the electrical industry, it was stated. Materials used include scrap costing 4 cents a pound, water which costs about 10 cents for 1,000 gallons, and silicone resins which cost about $ 3 a pound. Estimated cost of production of the finished material is about 15 cents a pound.

The plant making this material is located in New York State. Experts there found that a new machine called a 'disintegrator' could produce uniform surfaces in treated mica scrap which naturally adheres permanently after splitting.

The operation of splitting, under specified conditions creates a 'nascent surface' for mica particles, retaining adherent qualities which make little places cling together like overlapping shingles on a roof. In this way, sheets of pure mica can be made in the thickness ranging from fractions of a thousandth of an inch to as large as 3/8 inch.

The conference at which these data were presented was arranged at the request of Rear Admiral Rico Botto, Assistant Chief of Navy Material and Director of the Production Policy Division of the Navy. Complete minutes of the conference are to be published for National Association—Industrial Association members, it was learned.

So it will be seen that the technique of preparing synthetic mica and substitutes for mica has already been found. Now how far scientific knowledge thus acquired can be applied to industrial uses depends on the cost of manufacturing synthetic mica and mica substitutes. If these can be manufactured at less cost than the cost of producing natural mica from the mines then it is obvious that the fate of the Indian Mica Industry will be sealed forever and India will have to lose one of its important sources of earning foreign exchange, particularly dollars. Standardisation of mica is one of the means of combating the potential threat which synthetic mica holds out to the Indian Mica Industry. I conclude with a quotation from the Report of the Mica Enquiry Committee—1944-46 p. 47, which sums up the position quite clearly. I hope, the Mica Trade will not fail to give its fullest co-operation to the Indian Standards Institution for developing suitable standards for Mica.

> "According to the present practice, in which there is no uniform standard of quality, the correlation of prices from year to year and between firm and firm can not be made without a comparison of the samples representing the different transactions. Such a comparison is not possible, and both exporters and importers remain very much in the dark as to the real prices of mica, and depend entirely upon their own shrewdness and their capacity for holding out in order to get reasonable prices. In this mutual struggle between exporters and importers, the former, are at a disadvantage, as they are attempting to market abroad a product which has no outlet in their own country, and the bargaining power of the bigger producers who might be able to stand out for a better price is affected by the competition of smaller producers, who can not hold stocks abroad and are compelled to accept low prices. One reason for the suicidal competition between Indian exporters, which has been mentioned by several observers, is thus the absence of fixed standards."

SYNTHETIC MICA PRODUCED

BY

N. N. CHATTERJEE

It appears that the subject of synthetic mica and its preparation has been of sufficient interest and importance to those engaged in the Indian mica industry. In order to supplement the paper submitted by Mr. D. B. Sahana on this subject I have given below a quotation from the Queensland Government Mining Journal of 20th September, 1950 which gives some amount of details regarding the method of preparation of mica by synthetic process as carried out in U. S. A.

"Mica essential to radar and radio equipment preparedness, has been produced synthetically in substantial quantities at the Colorado School of Mines.

The results of the four-year research project at Golden, Colorado, under grant from the Signal Corps, have been announced by Dr. William C. Aitkenhead. The project was completed on 30th June, but in an economy move the U. S. Federal Government has not provided funds for additional work. Research has also been carried on, but with the use of crucibles, by the U. S. Bureau of Standards, Washington, D. C., and the Bureau of Mines at Norris, Tenn.

Cakes of mica, weighing up to 500 lb., have been formed at the Colorado School of Mines by a new "cool hearth" method. The process avoids the use of crucibles and contains the molten mica in a basin of unmelted raw mixture from which the melt was derived. Crystallisation takes place in this melting basin which forms a centre pool surrounded by a solid cool mass of the unmelted raw mixture.

A total of 24 furnace runs was made under terms of two Signal Corps contracts covering the four-year period, many of the runs employing a new practical, travelling hearth apparatus developed by Colorado School of Mines research directors.

The two largest contributions made by the mines school in the synthetic mica project comes in these fields—elimination of crucibles and employment of the travelling hearth. No crucible material has ever proved completely satisfactory, Dr. Aitkenhead states in his report. Platinum, probably the best yet found, is twice as costly as gold and much too expensive for practical use. In addition, the mica cake adheres tenaciously to the platinum, necessitating considerable battering of the crucible to remove it. Graphite is rapidly deteriorated by oxidation at the high temperatures needed to melt the raw material, and will always contaminate the mica with fine particles. Silica-alumina ceramics are all attacked by the melt.

To do the melting, a natural gas flame was played from above directly over the centre of the raw mixture. The material, forming the hearth of the furnace was caused to travel slowly (about one inch per hour) under the heat. Melting occurred on the leading edge, crystallisation on the trailing end of the molten pool. This made the process semi-continuous and provided accurate control of the cooling rate. The melt covered itself with a blanket of viscous defluorised material which appeared as a warty crust when the mica cake was solidified. This property of the melt in automatically covering itself impeded fluoride loss and made it possible to obtain fairly pure mica by crystallising a cool hearth melt.

It was thus possible to adjust the composition of the raw material of ingredients to compensate for inevitable fluorine loss, assuring a uniform fluorine content of the crystals. Low fluorine mica is hard and tends to show a glassy lustre. Mica with a too-high fluorine content is chalky and splittings reveal interlamellar impurities.

Mica of exceptional clarity and flexibility resulted. However, few crystal faces of sufficient size were produced, and when large faces were observed they were so thin and entangled in the crystalline mass that they were always broken in trying to extricate them. To meet commercial demands crystals would have to be produced in sizes of 1 in. x 2 in. at least, Dr. Aitkenhead, who has been on the Colorado School of Mines faculty since 1937, believes. Only a few as large as that have been produced.

Research directors believe that the best mixture of raw material is composed of pure potassium silicofluoride, silica, alumina and magnesia. Individual ingredients were ground together, very finely, to promote the most intimate contact between the particles. Best crystallisation was received, Dr. Aitkenhead said, in Travelling Hearth Run No. 5. The furnace was heated to a maximum of 1510 deg. C. in 11 hours. After two hours the temperature began to drop, indicating that melting had begun, and after 17 hours' total heating time the movement of the hearth was started and continued at a rate of 1 in. per hour for 20 hours. The furnace was cooled at a rate of 10 deg. C. per hour for 13 hours. "This test," the research director said, "gave the best crystallisation and purest mica yet produced".

The effects of seeding and rocking in efforts to bring about parallel crystallisation of larger particles were virtually nil. In one run seeding did cause parallel crystallisation to start but less than an inch up the cake gave way to the usual random formations.

Dr. Aitkenhead said : "We do believe, however, that a considerably deeper melt, cooled so that crystallisation from the top down would be avoided, would produce a certain yield of acceptable mica splittings, even though there were no parallelism. When one considers that those runs which produced fairly solid mica gave cakes six inches or less in thickness it will be realised that we have been able to gain a maximum of four inches of interrupted upward crystal growth.

If a mica cake of proper chemical composition one foot, preferably two feet, thick were slowly crystallised, it is our belief that some mica of commercial size would be obtained. Probably at best over half the product would be scrap. But a yield of 10 per cent utilisable mica should be acceptable. Some, if not all, of the scrap could be reverted to the process".

A large hearth, Dr. Aitkenhead believes, about 6ft. wide, 3ft. deep and as long as practical, would help produce a thicker cake of mica and perhaps better and larger crystallisation. He also recommends that the raw material mixture be pressed into bricks under high pressure of several tons per square inch. This should compact the material to give a melting shrinkage of 25 per cent, contrasted with 40 to 50 per cent. shrinkage when the mixture is tamped by hand. Some provision should also be made to saw the mica blocks into slabs to facilitate recovery and sorting of the usable mica.

Synthetic mica has essentially the same properties as natural mica, but is able to withstand much higher temperatures. General uses include bushings, sleeves and plates for electric motors, generators, electric coils, gas mask lenses and Christmas snow.

Experimentation in producing synthetic mica gained impetus in the United States after scientists and technologists discovered in the spring of 1945 how great had been the advance in Germany before and during World War II. It was to follow up this work and to verify German results that the U. S. Army Signal Corps entered into the project contract with the Colorado School of Mines at Golden."

NOTE ON THE MICA INDUSTRY

BY

W. D. WEST

The papers that have been contributed to this symposium seem to have dealt with almost all aspects of the mica industry in India—history, geology, petrogenesis, mining, standardisation, industrial aspects, labour welfare, the problem of synthetic and substitute mica, and even the question of nationalisation. The problems that face the industry are well known. The solution to these problems is, however, less easy to devise. I propose drawing attention briefly to one or two important matters.

In order to try and bring some order into the prevailing confusion, the Government of India in 1944 constituted a Mica Enquiry Committee, and the Committee's report was published in 1946. It covered almost every aspect of the industry, giving particular attention to devising some form of organised trading that would strengthen the industry's position *vis-a-vis* the purchasers abroad. It considered no less than nine different schemes before submitting its own proposals for a Mica Marketing Control Board. Unfortunately it was unable to discuss its proposals with the representatives of the trade in the three producing areas.

Arising out of the Committee's report, the Government of India set up an Interim Mica Advisory Committee to examine the Committee's proposals. This Committee has been meeting fairly regularly about twice a year for the last five years ; and as it is composed of representatives of all parties interested in the mica industry, both official and unofficial, it has enabled the different sides to learn each other's view points, in itself a matter of considerable value.

Apart from doing a lot of useful spade work in implementing the less controversial recommendations of the Mica Enquiry Committee, it has brought to light in a forcible way the many difficulties that face any scheme of co-operative trading in the case of mica, and has revealed that in many of the controversial issues there was a good deal to be said for the different points of view held, e. g. over the merits and demerits of exporting on a consignment basis.

Both the Mica Enquiry Committee and the Interim Mica Advisory Committee had the advantage of the experience of the Joint Mica Mission that operated in India during the war ; and it was perhaps this more than anything else that, paradoxically enough, emphasised the difficulty of setting up any form of organised trading.

It would take too long to discuss the various proposals and difficulties in this place. There are, however, certain points that may usefully be emphasised.

In the first place it is essential to standardise the various grades and qualities of mica. But this is easier said than done ; for until definite physical tests can be devised, it will never be possible to set up satisfactory standards which cannot be questioned. It should at the same time be mentioned, however, that many exporters have been carrying on business with their regular customers with their own standard samples without serious difficulty over a number of years, based largely on goodwill.

It has also to be admitted that much confusion, and indeed harrasment of the industry, is due to the fact that minerals are primarily the responsibility of the States in which they occur, although the Central Government controls the export of the minerals. It would seem most satisfactory if minerals were made solely the responsibility of the National Government. This, however, would mean amending the Constitution, and would no doubt be strenuously oppossed by the States.

Another problem that faces an industry that relies almost entirely on exports for its successful operation is the rising cost of labour. With sterling devalued, and many countries stock-piling, the mica industry happens at the moment to be in a relatively flourishing condition. But with a change in either or both of these factors, the industry may find itself in serious difficulties if the cost of production is so high that the mica cannot be sold abroad. And overshadowing all is the likelihood that if the cost of producing mica becomes too high, substitutes will inevitably be developed.

There are, however, certain directions in which positive action can usefully be taken.

It is important that a detailed geological and petrographical investigation of the mica-producing areas be undertaken. This has been started by the Geological Survey of India, but it has been delayed on account of the difficulty of getting large scale topographical maps prepared. The results of this work, if done in sufficient detail, may lead to the easier location of workable mica, quite apart from its scientific interest.

Research on the physical properties of mica, with a view to developing objective tests for standardising the mineral, should be undertaken energetically. This might be done at the National Physical Laboratory. It was recommended a year or two ago by the Interim Mica Advisory Committee, but no action seems to have been taken.

Steps should be taken to improve the standard of efficiency of those who are responsible for mining the mica. The Mica Enquiry Committee recommended the setting up of evening classes. and this proposal was carefully examined by the I. M. A. Committee. It is to be hoped that this recommendation will soon be implemented. It is largely a question of finding the necessary funds ; but as the industry has already agreed to the levying of a cess for this purpose, its institution should not be long delayed. It should ultimately lead to an improvement in the method of mining, and so to getting the maximum quantity of mica out of each pegmatite.

I believe that the work of the I. M. A. Committee would be improved and speeded up if the Committee were divided into a number of sub-committees dealing with particular aspects of the industry, and reporting to the main Committee for final decisions. There are so many sides to this industry that one large Committee cannot efficiently deal with all.

As regards the important matter of introducing some form of organised trading, I believe that it would be best at present not to interfere too seriously with the present methods. The mica industry has grown up over more than half a century, and it would be unfortunate to introduce drastic changes in its structure which might seriously damage it. It may be that the force of events will eventually lead to some form of co-operative trading, thereby eliminating the competition at present existing between so many large and small Indian exporters. But I believe in proceeding with caution, lest the remedy be worse than the disease.

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Ground Water in the Kaladgi Rocks*

BY
D. G. LIMAYE

Abstract

A basin of Kaladgi rock named after the town Kaladgi, lies in the Bijapur and Belgaum districts of the Bombay Karnatak. It covers an area of about 400 sq. miles. It has been notorious from historical times for scarcity of surface and underground water and though the soils are fertile, crops fail frequently for want of sufficient water. Scarcity of drinking water also is severe and villagers are required to go in summer months as far as six miles to fetch their day's drinking water. This portion of the country is undeveloped and neglected.

The author had occasion to study the whole area for ground water and his findings are given in this paper. The author is optimistic. He finds that the conglomerates, quartzites, shales, limestones, etc., though bodily impervious, hold and yield large quantities of permanent water in the joint and cleavage planes opened by disturbance and weathering. Water is deep but the supply may be copious.

The bedding and cleavage planes in all the strata in the Kaladgis are thus opened. Streams with their courses along the strike of the rocks and depressions help to saturate with percolating water the opened planes to some distance in the dip direction. This necessitates the selections of spots for wells and formulae have been developed herein for determining the distance of such spots from topographical lows, or sources of seepage.

Capacity of water from a well depends upon the number of cleavage openings struck by it. Suitable shapes for wells are designed and recommended. Formula for head of pressure has been developed. Possibility of artesian supply has been discussed.

The paper thus gives a discussion from all points of view on the ground water in the Kaladgi rocks. It is based on author's own observation in the field, as also experiments by actually digging wells and bore holes. The author has proved that this country is not to be regarded as desertic but has considerable reserve of underground water that can be tapped with proper arrangements and at proper depths which is sometimes as high as 150'-200'.

INTRODUCTION

The object of this paper is to describe and discuss the occurrence and behaviour of underground water in the several rock-formations of the Kaladgi series in the Bombay State. The area occupied by the Kaladgi rocks is from historic times, noted for scarcity of water both surface and underground. It is thus neglected and undeveloped. A traveller in the area feels satisfied if he gets the sweet water sufficient to quench his thirst in the hot summer day. The author of this paper had the opportunity of surveying out practically the whole of the area during the recent well digging schemes and his findings have been discussed here at length.

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* Read before the Society on 3rd September, 1951.

GEOGRAPHICAL DESCRIPTION

The southern portion of the Bijapur District of the Bagalkot and Badami talukas, parts of Hungund taluka, and the eastern portion of the Belgaum District, Gokak and parts of Parasgad talukas, together with Ramdurg and Torgal Jagirs, and parts of the Mudhol State, lie within the Kaladgi rock basin. The whole area lies within 75° to 76°12′ east longitudes and between 15° 20′ to 16° 20′ north latitudes. Rainfall of the area varies from about 17″ in Gokak taluka to about 24″ in Badami Taluka. The Kaladgi from which town the rock series derives its name, has the average rainfall of about 20″. Annual precipitation of rain deviates greatly from this average and there was 7.54 inches of rain at Kaladgi in 1857 while it was 30.54 in 1878. Heaviest rains occur in October as precipitation from the retreating monsoons. September, August and June are the months of lesser rainfall. Monsoon season is thus extended over five months. The whole area is open, windy and arid and summer months are very hot. The hottest month is April when temperatures at Badami and Bagalkot rise as high as 112°F during day time. The quartzite hills radiate heat and a summer day in the hilly portion is extremely oppressive. Heat is less intense in the plain and at Kaladgi which lies amidst the area and may represent the climate conditions of the area, the temperature in summer is 106°F in April and 48°F in January.

The area is devoid of vegetation except shrubby low jungle in its hilly boundaries. Few trees may be noticed in the plain to break the continuity of the vast stretch of land.

The area has the shape of a nearly rectangular trough or basin, with its boundaries at higher levels, a hill range girdling it with few breaks. The hill rises abruptly from the scarp side and slopes gently into the basin. It has usually a flat top with a narrow plain on it. The surface of the basin is undulatory and rugged, except near the bottom. It is covered with rich black soil for the major part and with favourable rainfall, the area yields rich crops. There are few gardens, and irrigated agriculture has not advanced due to shortage of perrenial water. There are few prominent hills within the basin.

Rivers that drain the area are the Ghataprabha and the Malaprabha. They enter the area through gorges and leave it through gorges or very narrow valleys. The Ghataprabha enters the basin through the famous Gokak Falls and passes out through a gorge at Herkal. It meets the river Krishna at Sitimani where the latter passes through a narrow valley. The Malaprabha enters the basin through the famous Navaltirth gorge about three miles or so in length. It passes out of the basin through a gorge cut through quartzite at about 6 miles to the east of Ramdurg. It then flows out around the southern and eastern boundary hill chain.

The land within the basin lies within the water-sheds of these two rivers. A water-divide between the Ghataprabha and Malaprabha runs from west to east through the basin dividing it into two halves. This water-divide starts from north-west of Yargatti (Tal : Parasgad) and passes to Hullegeri (Tal : Bagalkot) with a low crest rising at places into hills.

Smaller streams start within the basin and meet these rivers. The rivers are perennial but all the streams with the exception of the Sillikeri nala which is perennial, flow full only once or twice during the monsoon. They lead the rain water to the rivers and are dry for rest of the period of the year.

Aridity of the area, its low rainfall, torrential precipitation, undulatory and rugged topography, are all the features which do not favour percolation of rain water into the ground. The rivers flow through lowest contours and act as drains. Small streams, however, help percolation of water into the country rocks. Smaller depressions which feed these streams with rain water help percolation.

GEOLOGICAL DESCRIPTION

The Kaladgi rocks are best displayed within what is called the 'Kaladgi basin'. Outliers and inliers extend outside the basin only locally. The area had already been described by R. B. Foote (1876) but in spite of it a detailed description has been given here, even at the risk of much repetition, as the hydrologic discussions will constantly require reference to the above.

The Lower Kaladgi Series

Prominently and abruptly rising above the gnessic plain to the south and east are the steep scarp of the peripheral hills made up of the Kaladgi arenaceous rocks. To the west and north are the Deccan Traps overlying the Kaladgis with strong unconformable junctions. The bottom member of the arenaceous sub-series is the 'basal conglomerate,' which is found also in the northern and southern boundaries as at Bisnal (Tal: Bilgi) and at Hullikatti (Tal: Parasgad) respectively. Overlying the basal conglomerates are the quartzites or the sandstones as in the south-east corner (Badami) of the basin. The peripheral hill range is then comprised of these beds which are all arenaceous and may be represented by an abbreviated name the 'quartzites,' since the true quartzites are most prominent.

The strike of the peripheral quartzite series coincides with the run of the hill range and it turns in every corner so that a rectangular periphery is formed to girdle the basin within it. The quartzites then dip within the basin in four directions. The angle of dip has great local variation from 8° to 75°. The frequent dip however is 17° to 20°. Pitching folds are frequent in the quartzite series.

At places the quartzites are quite horizontal. At Pudkalkatti and Mailmatti in Gokak Taluka the sandstones with interbedded conglomerates and banded sandstones, are horizontal. They continue to be horizontal as far as Hire Nandi and Chikke Nandi villages. The area south of Nandi is occupied by sandstones and overlain by the Deccan Trap. These sandstones are altered into quartzites where disturbed. A fault is suspected about this area.

The true quartzites are bodily impervious and sandstones and the cherty breccia are porous. All the members of the arenaceous series are traversed by numerous joints, which are open with wtdth of even as much as an inch. The bedding planes are rent open and form joints running along strike with two sets of cross joints

The argillites follow the arenaceous series in the rising succession. They display very varied lithological types and varieties. Some are shales (Yargatti), some are schists (Manoli) and some are limestones (Anwal, Tolmatti etc.). Some of them may be called slates (Padamandi).

Beginning from the southern-most boundary in the Belgaum district, the Yargatti shales and the Manoli schists occupy the south-western corner of the basin. They are followed by similar shales interbedded with grits, sandstones and bands of quartzites between Yargatti and the river Ghataprabha to the north. The schists of Manoli are followed northwards in the direction of the dip by limestone of Chinchnur which are succeeded by the Padamandi shales which approach slates. To the north of Padamandi a quartzite band is seen at Torangatti and this is followed northwards in dip direction by shales interbedded with grits upto the Ghataprabha. The strike of all these argillites from the southern boundary upto Ghataprabha is nearly west to east. (or N.W. to S.E.). They dip nearly to the north all throughout, though vertical and southerly dips are noticed at places, (Budni-Guttigoli Tal: Gokak). Angle of dip varies much from 30° to nearly vertical.

It is interesting to note that the argillites in the southern portion of the basin within Belgaum district are shales, schists, slates and limestones upto half the distance northwards beyond which they are interbedded with bands of grit, sandstone and quartzite. The west-east strike and the northerly dip prevail from the southern boundary as far as the Ghataprabha, though they roll about. Isoclinal folding appears to have taken place with the argillites at places.

To the east of this portion in the Gokak and Parasgad talukas occupied by the argillites is Torgal-Ramdurg-Lokapur portion. The peripheral quartzite hill boundary encroaches within the basin east of Katkol. The Bundi-Guttigoli shales continue eastwards north of Torgal and pass into the limestone area at Khajjidoni via Lokapur.

The argillites pass eastwards into the Bijapur district. To the east of Ramdurg the agillaceous group of shales extends with west—east strike as far as the south-east corner of the basin where around Badami—the sandstones change their strike south-north. The argillites are typical shales as noticed at Chimmanakatti (Tal: Badami) where the most southern band is noticed. Here they are earthy, soft with beautiful pink colour. Northwards of this, pale yellow earthy soft shale is noticed at Radder Timmapur (Tal: Badami) with west-east strike and northerly dip. Then follows along dip the prominent sandstone band of Kerur From Kerur eastwards, the land is covered with calcareous cherty deposit (conglomerate) but deep borings at Halkurki 4 miles west of Badami, indicate that the typical rocks are argillites. The Kerur band of gritty sandstones has nearly west-east strike, and northerly dip. It is conformable with the shales to its south. Same beds are noticed at Shipparmatti about 12 miles to the west of Kerur. The Kerur band of sandstone is overlain conformably by shales which are seen northwards of Kerur. The Hulgeri shales are nicely displayed in the sections of well-pits at that village. These shales are gritty and interbedded with thin sandstone and quartzite bands all of them with west-east strike and dipping to the north with 30°. These shales continue eastwards. At Hullasgeri soft blue shale is noticed in the District Local Board well-pit, but it is sandwitched conformably between the Lakaskop sandstone band to its south and the sandstone prominently displayed in the hill to the north of Hullasgeri. The dip of shales at this place is 19° to the north-east. The shales continue westwards and are noticed at Karkalmatti west of Hulgeri where typical hard shale is noticed in the Local Board well near the Jagirdar's house.

Westwards of Karkalmatti is the Khajjidoni-Kaladgi area of limestone of which Shipparmatti-Anwal probably form the southern boundary. The pink soft limestone of Anwal is faulted against the sandstone which is horizontal and is interbedded with beautiful conglomerate. The limestone is pink and of soft variety and dips to the south from 12° to 30°. This fault is traceable as far as Shipparmatti. A beautiful green variety of limestone is noticed at Nire Budhial to the north of Anwal. Two beds of dark clay are noticed at Sillikeri one of which deserves to be called slate. It is nearly vertical with west-east strike, and is seen as far as Chikke Sillikeri. Further northwards of this are the Khajjidoni-Kaladgi limestones. The limestone at Khajjidoni has dip to the south with an angle of 19°.

The argillites continue as far as Ghataprabha northwards of Hulgeri. At Yedhalli on Bijapur Hubli road, five miles to the west of Bagalkot and four miles to the south of Ghataprabha, a typical hard bed of shale is seen in the wells by roadside. It is curicus enough to note that to all appearance this shale resembles the schist of Manoli (Tal : Parasgad).

The argillites in the Bijapur district, thus, maintain the west-east strike right from the southern boundary of the basin to the Ghataprabha, as is noticed with the argillites in the western half of the basin which lies in the Belgaum district. The argillaceous members in the eastern half of the Kaladgi basin which lies in the Bijapur district, are more siliceous and gritty with the typical earthy shales less predominant among them. They are more frequently interbedded with sandstones and quartzite bands and limestones are more frequent in them than in the argillites in the western half of the basin.

It is very interesting to note that with the exception of the limestone formations within the small area of Lokapur-Khajjidoni-Anwal-Kaladgi, the argillites within the whole portion of the basin from its southern boundary to the river Ghataprabha have the prevalent west to east strike and that the general trend of their dip is to the north. The shales are conformable with each other and with bands of sandstones, quartzites and limestones interbedded with them. Variations in characters of the shales have occurred in lateral extensions of the same beds. The argillites appear to have been overfolded with tops of the isoclinal folds removed by denudation. The compressional force appears to be from north and south as strike of all the beds within the basin is between west to east. The limestones of Khajjidoni-Anwal area dip to south but they are faulted against the sandstone band.

The argillites between the portion from the northern boundary of the peripheral quartzite hill-range and the river Ghataprabha to its south maintain west-east strike and have southerly dip as far as the Ghataprabha They occupy a narrow strip of about 10 miles width between the northern boundary and the river. They are pink, yellow blue shales interbedded with limestone conformably, all dipping to south, as far as the river.

The northerly dip of the argillites from southern boundary of the Kaladgi basin to Ghataprabha, and the southerly dip from the northern boundary of the basin to the river suggest their synclinal structure with the river flowing along the axis of the syncline.

The lower Kaladgi formations are classified as follows by R. B. Foote (Mem. G.S.I., Vol. XII, p. 71) :—

1 Quartzites, conglomerates and sandstones 2 Siliceous limestone and hornstone or cherty breccia.	Peripheral series.
3 Sandstones and shales. 4 Limestones, clays and shales.	With exception of Khajjidoni Anwal limestone, strike nearly west to east and dip (with isoclinal folding ?) to the Ghataprabha and to the south from the northern boundary nearly to the Ghataprabha.

The Upper Kaladgis :—The Upper Kaladgis is a group of rocks which overlie conformably the Lower Kaladgi argillites. The Upper Kaladgis occupy small patches. They are frequent in the north-eastern quadrant of the Kaladgi basin. It is not necessary to describe them in detail here.

The Deccan Trap :—Overlying the Kaladgis unconformably are the extensive outliers of Deccan Trap rocks. They occur throughout the basin. The southernmost of the outliers is at Ogalapur topping the hill to the north-east of Ramdurg. An extensive outlier is noticed between Kerur and Hulgeri, Kerur and Jungwad to Shipparmatti. A third very extensive outlier is noticed from about 5 miles to north of Yargatti as far as the Nandi villages with its peak at Tavalgeri. It extends as far as Kopp to the east. A bed of red coloured grit underlies the trap-rocks of these outliers and this grit is best displayed at Madamgeri.

The superficial deposits are considered later.

GROUND WATER CONDITIONS.

Ground water has different mode of occurrence in different formations. The formations are therefore considered differently as follows.

The basal conglomerates :—The basal conglomerates of the lower Kaladgis have quartzitic texture and are quite impervious when fresh. Their pebbles of varying sizes, some of them as big as an inch cube, are all completely cemented together. The thickness of the basal conglomerate is not frequently more than 2 to 3 feet. Yet at Bisnal in Bilgi peta, plentiful water is obtained from weathered basal conglomerate which has thickness here of about 40 feet. A well located by the author has yielded plenty sweet water. The conglomerate is susceptible to weathering and at Bisnal the 40 ft. of conglomerate is all weathered into sandy mass with its original fragments separated. It yields large supply of water. The well is far to the south of the fault and yields water independent of the influence of the fault. No well was noticed in the basal conglomerate at any other place.

The peripheral quartzites and sandstones .—The true quartzites of the peripheral zone are impervious and are devoid of connected pore space for water. The rock is also extremely hard for digging and it is apparently erroneous to expect water in wells in these quartzites.

But the quartzites of all the periphery are intensely jointed. All the joints are open. Rain water percolates down these joints and is stored in their net-work so long as it is not drained away through a natural spring or finds no other outlet. Mostly however the water is drained off through natural springs in dip direction or on scarp face.

The folds in quartzites help storage of water in the joints in the synclinal bottom. Water percolates in the joints from both arms of the synclinal fold and plentiful supply is obtained in a well in the axis of the fold.

In the quartzite area there are some villages which need water. Some of them get water from natural springs. The author located a spot for a well at Gorobal (Tal: Parasgad) a village situated in a fold in quartzite. The village suffered from scarcity of drinking water. The author fixed a spot in the axis of the syn-fold. Quartzite was blasted out from the very surface and sufficient water was tapped at depth of 70 ft. One would have felt it absurd seemingly to have thought of getting water at such place but it was actually obtained and the well is happily used by people. The author has located site for a well under similar conditions at Janmatti (Bilgi). The bores at Yellamma Temple on the outlier of the Kaladgi quartzites to the south of the main basin, the natural spring in the main fort there, are good examples of the existence of water in joints in quartzite.

The sandstones of Badami are comparatively porous and are traversed by similar jointing. Water is obtained from the porous sandstone and from the joints. Wells in Badami sandstones yield water from 30 to 100 ft. depth depending on the topography of the well site. Plentiful supply is available at places. Brackishness of water is due to pollution from surface sources.

At Pudkalkatti (Gokak Tal) the horizontal sandstone (gritty) interbedded with conglomerate did not yield water in a well at the village. The topography of the well-site was not favourable for getting water, but water was expected as the sandstone was strongly jointed Water was not however obtained in a well bored to 100 ft. depth and a deeper trial was obviously necessary. Some water is obtained at Mailmatti (Gokak) from the sandstone which here is quite horizontal and jaspery and banded at places.

A well of 70 feet depth dug in quartzite talus at Mannikeri (Tal: Bilgi) about 8 miles east of Bilgi did not yield water. Quartzite taluses at all other places in scarp-side yield plentiful supply.

A well located by the author at Piyali seven miles from Phonda (District Ratnagiri) in sandstones yielded copious supply of water only within 8 feet depth. Similar sandstone yields water in deep and shallow wells in Rajapur Taluka.

The argillites:—Argillites of Kaladgi series are commonly considered to be non-water-bearing. People get disappointed when they get shales or "Kattak" in a well, and believe that water may not be tapped. The argillites however do yield water, the only difficulty being that it is only at great depth, so that in most cases failure to get water in wells is due to failure in not going to sufficient depth to get the water.

The shales are impervious unless they are gritty or arenaceous. But all the shales of the Kaladgi series are as a rule opened upto the depth from 30 ft. to 200 feet or 250 feet. The shale in the opened zone preserves its body structure and texture but the cleavage or bedding planes are widely separated due to disturbance and weathering. Considerable space is available along these planes thus opened and water gets stored in this space. This enables the argillites to hold considerable quantities of water under suitable circumstances. But deep digging is often necessary for wells and it is a difficult and dangerous task as the sides are apt to collapse. Boring is also troublesome in the dipping shales with opened cleavages. This makes well-digging a very costly affair and it is done only when it is absolutely needed. The tract may therefore be considered to be non-water yielding.

There are some bands of shales which are completely weathered and turned into earth or ochre. The body of the shale is weathered and disintegrated and weathering has advanced further than the stage of opening of the cleavage and bedding planes. Loose incoherent ochre is obtained in some wells or bores and the task is then so troublesome that it is required to be abandoned.

Even then the shales in the Kaladgis yield considerable supply of water at reasonable depth under favourable conditions. The depth of water in the shales depends upon (*i*) zone of weathering (*ii*) topographical situations of well-site (*iii*) angle of dip (*iv*) relation of topography with the dip. These will be discussed later on. It is sufficient to state here that water is obtained from shales of the Kaladgis within depth of 30 ft. to 200 ft. or little more.

The argillites of the narrow strip from Halgali (Mudhol) to Herkal (Bagalkot) need a special consideration. They are discussed in later pages.

Argillites in the area of Gokak and Parasgad Talukas including the former State boundaries:—The village Yargatti stands on shale on the water-divide between the Ghataprabha river to its north, and the Malaprabha to its south-east. The well of the Public Works Department at Yargatti, by side of the Belgaum Bagalkot road, is about 150 feet deep but does not yield water. Other wells of lesser depths tried round about have also failed. There is an old village-well about 2 furlongs to the east of the village and it is about one hundred and seventy five feet deep from ground level. This well yields plentiful supply of water. The villagers find it troublesome to lift water from such depth and they use the tank water. A scheme is now introduced for pumping out the water from this well for two villages Yargatti and Rainapur about 1 mile from Yargatti. A recuperation test of this well has been taken and it is found that a supply sufficient for requirements of the two villages shall be available from this well. This is a very good example of occurrence of underground water in the shales and a very good case indicating the depth of water. The topographical situation of this well is not striking and yet plentiful water is available. At Yarzarvi (Tal: Parasgad) the shales were blue, typically argillaceous, underlain by a variety of shales pink red to yellow red in colour and softer in nature. These shales are overlain by Deccan Trap outlier which is seen on the hills and which is met with in the old well at the village. Another old well had been dug at the instance of Pagson an old water-diviner of the Bombay Agricultural

Department. Pogson's well was 88 feet deep and had failed to yield water. There was a Local Board well of 20 feet diameter and 100 ft. depth about 3 furlongs from the village and this also did not yield water. From these instances the public thought that the shales had no water. The direction of slope, the surface drainage along the strike were all favourable for water storage underground and so the author recommended that the shales at the village are water bearing and that water should be obtained at any place. He recommended the Local Board well to be deepened to 140 ft. and suggested a new site for a well of 150 ft. depth. He predicted a supply of 30,000 gallons a day on the basis of calculations of probable run off from the catchment and co-efficient of run off, of co-efficient of percolation (influent seepage) and dividing it by 360 (days). Bores were taken in the Local Board well and this supply has been obtained. A well was located by the author at another village Bidikop (Tal: Parasgad) A bore of 118 feet met with very soft earthy shale or ochre through which boring could not be done. Another site was taken by the Board where water has been tapped from 117 feet downwards and the bore is 130 feet deep. It is curious enough that trap rock is obtained in this bore till 105 ft. depth at which water level stands and as the author is informed, water is obtained from the underlying shales. At Torangatti about 3 miles to the south-west of Katkol on Belgaum-Ramdurg road, several trials were taken of wells and bores as deep as 100 to 140 feet. Yellow ochre was met with in all of them and further depth could not be approached. Water was not tapped within this depth but a still deeper trial may yield water from a harder underlying shale. The shales at Hoskatti are pale green blue to reddish, and they maintain their west-east strike and are nearly vertical here. They are hard and deserve to be called phyllites as they have appearance of a phyllite. These shales yield water in a well of 115 feet depth but the capacity was not sufficient to the requirement of the village and of other villages in vicinity. The author advised deepening of this well for more water as the cleavages opened even by ½ inch suggested deep available space. The site was not in a depression. The shales at Budni are interbedded with thin quartzite bands and are hard slaty shales. To the south of Guttigoli hill where the shales are nearly vertical or dipping to the south with 85°, plentiful shallow water is obtained at low sites at Kamkeri. The Benkatti well yields plentiful water at 100 ft. depth while the wells in Manoli schists yield water from 30 to 60 feet depth. The Pademandi slates have not yielded water in shallow wells tried by the villagers and deeper trials are obviously necessary. It is costly to dig out wells in this rock. The shales at Rainapur yield some supply from 100 ft. They are pale green blue shale and more massive. A well about 2 to 3 furlongs from Aladkatti yields plentiful water at 131 ft. The shales here have more southerly strike (N. W. to S. E.). All these examples prove the occurrence of plentiful deep water in the shales.

Argillites in the areas of Badami and Bagalkot Talukas south of Ghataprabha:— Beginning from the southern boundary, the Chimmankatti (Tal: Badami) shales yield water at about 100 to 125 ft. depth. They are beautiful pink shales with cleavage planes opened. The bore tried by the Local Board at about a mile to the south-east of the village Halkurki has tapped water at depth of about 150 feet from ground level though it is quite on the bank of a stream. The water is from shales and it is very costly to dig a well of that depth. At Radder Timmapur (Badami) the author advised a well of 100 ft. depth in the shales, which are of pale yellow soft and haematitic-red hard varieties. The well has tapped water accordingly. Another well 2 miles off is about 100 feet deep and yields plentiful supply.

The gritty shales and sandstones of Kerur yield plentiful water at topographically low sites and wells in the village and Kelawadi yield large supplies. The quality is brackish in some wells due to pollution from surface sources. Some wells are used for irrigation. Wells at Jungwad yield good supply. Wells at Lakaskop (Badami Taluka) yield copious supply from the gritty hard shales here. They are overlain by a band of sandstone which in turn is overlain by a fine soft blue shale at Hulasgeri. The Local Board well pit at Hullasgeri is 72 ft. deep and has not tapped water. The author suggested this well to be bored to about 200 ft. as the depth of weathering in Kaladgi shales runs up to 250 ft. and a depression with a large catchment lay both to south and north. The well at Hulgeri on the Bijapur-Gadag road is noted as the deepest well in the district. It is 145 ft. deep but has tapped little water. There is large catchment to the south of the village which may help percolation of water and as the shales dip to the north, the well should have obtained this water. But the well stands exactly between two bands of quartzites which are interbedded with the shale here. One band of about 10 ft. thickness is noticed just on the southern boundary of the village Gamthan and is about half a furlong to the south of the well. This quartzite band obviously cuts all percolation passing along dip direction through the opened cleavages. The well has therefore failed to get advantage of obtaining water from percolation from catchment to the south of the village. The quartzite band to the north of the well cuts any water leaking from that side through the joints. The well therefore yields scanty supply percolated in the narrow strip between the two quartzite bands. The author has advised the well to be bored through the southern quartzite band and has recommended alternatively an altogether new well to the south of the southern quartzite band, so that this new well will yield water from the shale.

The shales at Karkalmatti yield plentiful supply of water within about 110 ft. depth. The shales at Yedahalli which are similar in appearance to the Manoli schists yield plenty of water for irrigation from shallow wells. These examples also show occurrence of water in shales.

The argillites in the narrow strip to the north of the Ghataprabha :—The shales from the northern peripheral quartzite boundary up to the Ghataprabha, form a narrow band striking generally west-east with local modifications and dipping to the south. In this narrow band are the villages Halgalli, Janmatti, Sunag, Tolmatti, Tummarmatti up to Herkal. All these villages are famous for scarcity of water. The shales are typical argillites, gritty as at Sunag, and calcareous as at Tolmatti. They are weathered as the shales in the rest of the area. The land in this narrow strip slopes towards the river with a perceptible gradient. The soils are very deep black soils and very fertile. A bore-hole tried at Halgali about half a furlong to the south of the village, passed through 80 ft. of debris and then through 100 feet of a formation which must have been shale as seen from the soft earthy soapy mud of pink colour, taken out from the sand-pump. No water was tapped in 180 ft. depth. Another bore was tried at distance of about 2 to 3 miles to the south-east of the village. It has reached about 100 ft. depth and it was reported that it has passed through limestone. Wells have failed at Janmatti while several trials at Sunaga up to depth of about 150 ft. did not tap water. They are soft shales and caving in side-walls occurs in old wells. All wells and bores at Tolmatti have failed to yield water from the shales and blue limestones.

This area is noted from historical times for its scarcity of surface and underground water. The author however believes that real test has not been applied unless a trial bore of at least about 250 ft. is taken. Natural conditions for getting underground water are not very favourable for this strip. The rainfall is smaller, the area is more arid and hot, favouring quicker evaporation. Soils are heavy and thick so that there is less percolation, the land falls fast so that there is less useful catchment. Lastly most of the streams pass along dip direction, so that percolation from streams gets dispersed into several cleavage planes, and thus the cleavages do not get richly filled. The argillites of this area are considered to be dessicating generally. The author has located wells elsewhere which actually got water from similar shales which previous to his visit were also thought to be dessicating. The argillites of this strip have cleavages opened up by disturbance and weathering and thus their structure is not unfavourable for getting water. The author therefore reserves his opinion that the portion is non-water-bearing unless a trial of about 250 ft. is studied.

The Limestones :—Most of the limestones yield water like shales from the cleavages and joints opened by weathering. This is nicely seen at Yadwad (Gokak) where shallow wells at good topographical positions of low sites with streams flowing nearby yield water from the bluish green limestone at that place. The soft pink limestone to the south of Chinehnur (Parasgad) appears to be water bearing but the hard blue limestone of Chinehnur does not yield water in wells tried.

The limestone yields plenty water at Anwal (Badami) to Sillikeri. The limestone of Khajjidoni has yielded enough water in a well located by the author. Sufficient supply was struck here at 110 ft. depth. This case is again discussed in later pages. Plenty water is obtained from limestone of Bagalket, the capacity and depth of water depending on topographical situation of a well. Water is obtained from 40 ft. to 80 feet depth or more. The limestone at Kaladgi appears to be hard and compact and results of deeper trials are not available. Same is the case with the beautiful green or blue limestone of Tolmatti where shallow trial pits do yield temporary supply. These pits dry during summer and deeper trials need be taken for experiments.

All the limestones of the Kaladgi argillaceous series are impervious in mass but their cleavages have been widely opened by weathering and water is obtained from these. As with the shales of the area, water occurs at greater depth than usually expected or at depths to which wells or bores can not be conveniently tried with the available tools. The limestones have the same structure as the shales as regards storage of underground water and behaviour of ground water is considered for all the beds together.

The Superficial deposits

The calcareous conglomerates :—Cherty calcareous deposit which has been called conglomerate overlies superficially the Kaladgi rocks usually the argillites of the lower series and the cherty calcareous breccia of Foote. The deposit is usually thin but it yields good supply of shallow water within 15 feet depth in wells about 4 miles to the north of Manoli. Extensive spreads of this formation are noticed between Melligeri and Halgali (Mudhol) Badami and Halkurki (Badami) and locally at Budipop (Parasgad), etc. Wells were not noticed in these portions.

The ferruginous deposits :—Ferruginous deposits from quasi-lateritic nature to red and yellow earths are seen frequently overlying the Kaladgi rocks. The former covers the narrow plateaus on the top of the peripheral quartzite hill range while the latter covers lower areas. The deposits are however not known to yield water as deep wells are not tried in them. The people think it a calamity if such deposits are met with while digging a well. Wells were tried in such deposits at Tondikatti (Tal : Gokak) and at Tummarmatti (Tal : Bagalkot). Extensive spread of the deposit is noticed at the latter village. Two bores of 100 feet depth and one well of the same tried even on the bank of the tank at that village have failed to yield any supply of water. The deposits are too open and highly porous so that water escapes downwards.

Some other deposits such as siliceous cherts etc. are local and unimportant. Taluses of quartzite fragments yield water in all the wells along the foot of the scarps while water is not obtained from such deposits in wells of 100 feet depth dug at Halgeli (Mudhol) and Mannikeri (Bilgi) where thick debris of quartzite fragments is spread at the foot of hills. Water is stored in fragmentary taluses where the floor for them on the scarp side is the gneiss, while in dip direction within the basin the floor is the shale. Water escaped down into the shale and hence the taluses within the basin are dry.

The Upper Kaladgis :—The upper Kaladgis are not generally important from the point of view of ground water resources as few wells have been tried in the inhabited area of these rocks; but plentiful water is obtained from the author's well at a depth of 70 ft. at Arkeri from the weathered sandstone of the Upper Kaladgis.

The Deccan Trap rocks :—Extensive outlier in the north-west quadrant of the area is spread from 4 miles east of Mudhol to 54 milestone on Kaladgi Yargatti road then westwards through the ridges of Kollur, Tavalgeri (Gokak) and northwards of Ghataprabha. A typical red bole bed of 5 to 7 feet thickness is noticed at Tigdon below the bridge across the Ghataprabha on the road from Gokak to Yadwad. The red bole is conformably sandwitched between trap rocks and is water bearing at suitable places. Bores at Tavelgeri yielded water, but the quality was brackish due to pollution from surface. Trap rock has spheroidal weathering at places and at Yarganvi, Mellikeri, Sattegeri (all in Parasgad) it yields water at 30 ft. depth. The water at places is polluted due to vegetation in stream beds. The outlier at Ogalapur is water-bearing and a natural spring issues out from below a Tal to the east of the village. The outlier to the north and west of Kerur is thin and wells were not seen in it. Other local outliers as at Yarzarvi are not important.

ARTESIAN CONDITIONS.

The dipping water bearing cleavages give rise to artesian or sub-artesian pressure determined by the equation $H = s \times \tan \angle \text{dip.}$, explained further.

The basal series of conglomerates and quartzites occupies topographically higher positions and water tables in them are at higher levels than sites in the basin. They dip within the basin from all sides and the argillites overlie them. The argillites are bodily impervious and completely impermeable below the zone of their weathering. It is possible that the peripheral arenaceous series has extended far within the basin under the argillites. Several situations occur where the ground occupied by the argillites is at a lower contour than the water table levels in the quartzite area.

Opening of joints of the basal quartzite (arenaceous) series does not appear to be a result of weathering only. Opening of joints has occurred practically everywhere and the upheaval of the rocks seems to be the chief cause of the renting of the joints. In wells at Bisnal and in the case of Gorobol cited above it can be noticed that weathering has advanced from surface downwards. Naturally therefore joints of the arenaceous members underlying the compact argillites within the basin may have been opened and thus become water bearing.

If the arenaceous series extend in this manner under the argillites within the basin, water in their joints must be under artesian pressure or under highly sub-artesian pressure under the unweathered compact zone of argillites. Sites for artesian supply may therefore be obtained looking to the topographically favourable situations in the basin.

This conclusion is based on the assumption that the basal members extend inwards into the basin without an overlap so that the argillites do not directly rest upon the Archaean floor.

Some sandstone members interbedded with argillites occupy higher topographical positions and water tables in them occur at much higher levels than some land occupied by the argillites in the dip direction. This may give rise to sub-artesian conditions depending on the depth. Sub-artesian conditions may also arise due to unweathered interbedded quartzite beds as seen at Hulgeri well.

QUALITY OF WATER.

All the water obtained from the Kaladgi rocks is pure in quality in the sense that it is useful for drinking and for irrigation. Water of impaired quality is obtained in few cases only.

Water from a bore at the Yellamma Temple yields water from quartzites which has some unpleasant smell. This appears to be due to decayed organic matter which finds its way directly down through the fissures in the quartzites; water from quartzites at Gorabal is quite pleasant.

The well in shales at Rainapur yielded water which had sulphurous odour. No other well in the Kaladgi shales is known to yield water with such odour. Wells at Badami and Kerur yield brackish water. The reason is that infiltrations from waste water from the villages, manure pits, reach such wells. Wells on the outskirts and beyond the village boundaries yield quite sweet water, while those in the central part of the village are the worst. Wells in abandoned localities are also brackish due to the same reason. Water in wells at Anwal yields brackish water from limestone due to the same reason.

An interesting case at Yadwad (Gokak) may be quoted here. Wells in Yadwad yield quite fresh or sweet water from opened cleavages of the otherwise hard and impervious blue limestone and finely laminated white, green or drab coloured calcareous shales. They have weathering in such a way that the mass of the blue limestone is disintegrated from surface downwards to some depth, so that worms bore out holes into it. Deeper down the body of the limestone and calcareous shale is unaffected by weathering but the cleavage cracks are opened. Water escapes down quickly through the opened cleavages so that it has no solvent action on the mass of the disintegrated limestone ; moreover a stream at the village drains off water from the mass of the disintegrated portion of the limestone. Water in the stream therefore gets brackish as percolation reaches the stream passing laterally through greater mass of the disintegrated material. Water from the same stratum from greater depth is sweet while it is brackish only in the upper portion where mass of the stratum is disintegrated. The villagers use the disintegrated portions of these beds for preparing what they called 'Nitre.' The disintegrated material is taken and puddled with water and the solution decanted. They said that 'Nitre' is left on evaporating pan. It was also said that 'common salt' is obtained from the soils and the disintegrated portion of the shales in the same manner. Some common salt is said to have been actually prepared in this manner during the 'Salt Satyagraha' days of 1931.

Leaving such exceptional cases, water from all the beds of the Kaladgi rock series is of quite useful quality.

Biological pollution from roots of some vegetation in stream beds has turned the water malarial at Madamgeri, Yarganni Mellikeri (Gokak).

THE HYDRAULICS.

Hydraulic consideration for underground waters in the rock beds of the Kaladgis is simple. Water has free movement in the cleavages and joints of the strata as it would have in pipes but the former are often filled up with ochre, which is yellow or red. Occurrence of ochre in the openings along the cleavage planes may initiate capillary movement of water within the opened plane.

The quartzites and the argillites are impervious and impermeable in mass and movement of water is not possible across the cleavage cracks which again agree with the bedding planes, except through the cross joints. If movement occurs at all through the mass of the sandstones it is only partial and restricted. Water may flow through the sandstone only under pressure and it shall follow movement through the partings unless obstructed.

The argillites of the Lower Kaladgi series are closely laminated and their lamination planes, bedding planes and cleavage planes agree with each other except in a few cases. They are opened by disturbance and weathering but cross joints are comparatively scarce. The sandstones are intensely cross jointed but the shales have few joints across the strike.

The lesser the number of cleavage openings cut by a cross joint, the lesser the effects on the integral contour joining the tops of the water table in different cleavage planes. The influence due to cross joints on water tables is therefore neglected in the following consideration for water in the argillites.

The cleavage planes, laminae, bedding planes which are normally the same with the argillites of the lower Kaladgis, get closed and compacted (sealed as it were) below the depth of 250 ft. Percolation of water through these cleavages opened stops over a horizontal plane below which the strata are unweathered and no openings exist. The water-table therefore rests over the bottom of the zero of weathering which is roughly a horizontal plane, since weathering may have uniformly taken place in the argillite formations the depth of weathering being considerable. A water-table in the Kaladgi rocks is of discontinuous nature and is comprised of separate water tables in individual partings separated by the bodily impervious partitions of rock mass between the laminae.

The path of percolating water may now be considered. Water percolates through the cleavage partings, which are dipping in a certain direction, and is carried off to some horizontal distance from the place where it enters a parting. This distance depends upon the angle of dip and the depth of zone of cleavage opening.

Greatest percolation of water occurs through depressions, streams and rivers. The Kaladgi argillites have very generally a west to east strike. Considering a depression oriented east-west or a stream flowing west-east or vice-versa, it is obvious that percolation occurring through the bed of the stream passes in direction of dip at some distance either to the north or south of the direction of dip at some distance either to the north or south of the stream as the dip may be. A percolation is greatest through stream-bed, water table has naturally greatest thickness at some distance to the north or south of the stream and not directly under the streams. The thickness of water table then falls on both sides as percolation from the sides of the stream valleys is less. This is explained by Fig. 1.

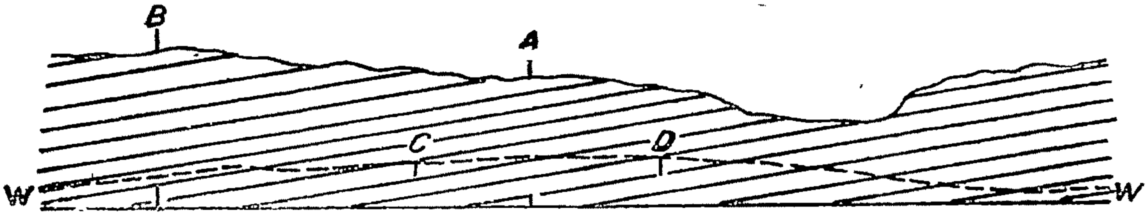

FIG. 1.

Diagrammatic cross section along dip showing thicker water table and sites for wells at distance from stream. W—W: Contours of water tables in the partings. C—D: Contour of water table at maximum height. A—B: Sites for wells A being ideal site. Wells can be most successfully dug between A and B.

Water table in the Kaladgi rocks are thus comprised of several seams of water in cleavage partings. It is not a mass of water embodied in the interstitial space of rock-body (except in the superficial deposits and partially in sandstones). Capacity of yielding water of a water table at any point therefore depends upon (*i*) the capacity of water in every parting (*ii*) number of such water-bearing planes in a unit horizontal length along dip direction. The first factor depends on the volume of open space in a parting and quantity of percolating water filling it. A highly cleaved weathered rock is obviously capacicus.

The distance at which water table gets thickest in dip direction from a stream flowing along strike is thus found

$\because$ Tan ∠. dip= $\frac{d}{D}$, where *d* is the depth of cleavage-opening and D is the horizontal distance from the stream at which the water table gets thickest.

$$D = \frac{d}{\text{Tan } \angle \text{ dip}}$$

The streams in the Kaladgi area with the exception of one or two flow during monsoons only. The cleavage partings get filled with percolation water during that period and there is no replenishment in the rest of the period of the year, if this water is lifted from wells.

The head of pressure on water in these formations is discontinuous. Different heads function on seams of water in different cleavages. Considering a single seam, the pressure at the bottom of the seam depends upon the angle of dip and the height down to which the cleavage parting is filled with water. Seams with greatest pressure can be followed from fig. 1 and they are at a distance in dip direction from a stream. The height of saturation of water in a cleavage plane may be taken as constant along its strike direction. The head H at any point in the dipping cleavage plane is

$$H = h_1 \text{ (total head)} - h_2 \text{ ('position head' at that point)},$$

The total head depends upon the depth of weathering and height to which the cleavage plane is filled with water and the 'position head' depends upon the vertical situation of the point above the zone of weathering. Hydrostatic head of pressure at that point is obviously a function of i where i is the horizontal distance in dip direction of that point from the highest water level in that cleavage plane, Hence

$$\because \quad H = f(i)$$

$$\because \quad \frac{\delta H}{\delta i} = \text{Tan } \angle \text{ dip}$$

$$\therefore \quad \delta H = \delta i \times \text{Tan } \angle \text{ dip}$$

The variation in the head H is equal to variation in horizontal distance multiplied by Tan ∠ dip. For any intermediate value of i not only less water will be obtained due to proportionately smaller value of H, but water from the cleavage plane from lower side of the well or bore, below that point will not rise into the well or bore above that point where the plane is struck through by that well or bore.

There were two wells at Khajjidoni (Kaladgi) in the limestone at that place. They were just on the side of a big monsoon stream close to the village. The limestone dips 19° approximately to the south The well to the north was 90 feet deep and yielded 1000 gallons of water per day, while the second well which was only at a distance of 20 feet to the south of the first well was also 90 feet deep but yielded only one hundred gallons of water per day. This considerable yield of water was obviously due to the dipping of the water bearing cleavage planes. The author advised the second to be deepened to depth of 110 feet from ground level so that it would yield about gallons of water per day. This recommendation was based on the above equ $\delta H \times$ Tan $\angle$ dip The water bearing cleavages of the first well would have beer in the 2nd well only by deepening it by 7 feet for a supply of 1000 gallons from 2nd well but as more water was needed, a greater depth of 110 ft. was recomme thus giving a further deepening of about 14′ and increasing the yield by 4 × gallons more. The yield of 5000 gallons of water has been calculated by cou the average number of water bearing cleavages per unit length. On boring the wel quantity was actually obtained.

When streams flow in the dip direction or against the dip direction percola water from stream bed enters the numerous cleavage planes running across the be the stream. A cleavage parting gets water from the stream and water percolates a cleavage through a very small portion (width of stream) of its own length. Thro cleavage partings, actually observed to have been opened continuously to dept even 115′ water has free movement through the cleavage and it spreads for a l distance on both sides of the stream along the length of strike of the cleavage pl As a result of this the water in a cleavage gets comparatively much smaller in thickn unless the stream is perennial. Thus the thickness of water in a cleavage plane is co derably small but its spread on both sides of stream is considerably extensive whe stream passes across the cleavages (that is along or against dip direction) than whe passes along them (that is along strike direction). In the latter case the water table actually shifted to one side of the stream (in dip direction).

LOCATION OF WELLS AND POSSIBILITY OF INCREASING THEIR NUMBER.

The object of locating a well is to find out a spot where a well would yield greatest supply of water. It is therefore necessary to consider the relation of depressi and of streams with the strike and with dip directions of the strata.

The greatest supply of water shall be available in a well dug where it gets adv tage of greatest thickness of the water table. Thus wells must be at some distance the dip direction from streams or depressions passing along strike, the distance dependi upon angle of dip of strata. The width of such a tract will be equal to that of t stream or depression, and its length parallel to the stream course. The well must pa through bottom of the zone of weathering. The quantity of water cannot be estimat mathematically as for Deccan Trap wells, since it depends upon the number water-bearing partings tapped and on the capacity of every parting. Yet with caref observation by an experienced worker the probable average number of water-beari partings can be estimated per unit depth and capacity of unit depth can be determin with careful trials. A rough estimate of capacity of a well can be thus predicted a the author has done it successfully in many wells cited in previous pages.

The capacity of wells fed by percolation from monsoon streams which have the courses in direction at right angle to the strike, is smaller than that of the wells in t previous circumstances. Percolations from such streams reach a considerable distan across, the thickness of water bearing strata is small and the capacity low. Wel therefore yield water but the supply is scanty to moderate.

Of the Kaladgi area in general it appears that a well or bore at any site does not otally fail to yield at least a scanty supply of water, as is the case with the Deccan Trap ountry. Water is almost sure in the Kaladgis if trials are taken sufficiently deep he supply may be insufficient for the particular requirements but water is obtained if he bottom of zone of cleavage opening is dug through. It also appears that, the wells r bores which at present seem to have failed to yield even a drop water seem so ecause they have not reached that bottom. As a matter of fact there would be very ew true failures, excepting where under adverse topographical and rainfall conditions here is scarcely percolation of water in the ground.

The wells in the Kaladgi area are moderately deep and as such they are not used for agriculture. Their recuperation test is seldom available as water is lifted from such deep wells only when it is badly needed. The public do not enthusiastically try digging for this reason and trials still deeper are not available.

But with the observations made by the author he believes that a very great number of capacious wells can be dug at thousands of suitable sites in the Kaladgi basin which has so long been considered as a famine tract. There will be moderately deep wells. If an economic pumping scheme is then introduced the so called dry Kaladgi basin can be developed in all respects that need water.

Several wells were noticed which yielded water from 5000 to 20,000 gallons per day. Greater capacity of wells can be had by increasing the diameter of wells and bored wells. The area is most suited for bore-wells.

DISTANCE BETWEEN WELLS.

Wells take away one another's supply if the same water bearing partings are cut by the two wells. Correct spacing of wells is therefore necessary and it must be so done that with the adjustment of distance between two wells they do not cut the same water bearing seams.

The proper distance between two wells along the dip direction of the strata is governed by the angle of dip. A well piercing the bottom of the zone of cleavage opening drains a dipping cleavage parting from its top to bottom which has been struck by the well anterior in dip direction. For distance S,

$$S = \frac{H}{\text{Tan} \angle \text{dip}}$$

where H is the vertical height of water in the parting.

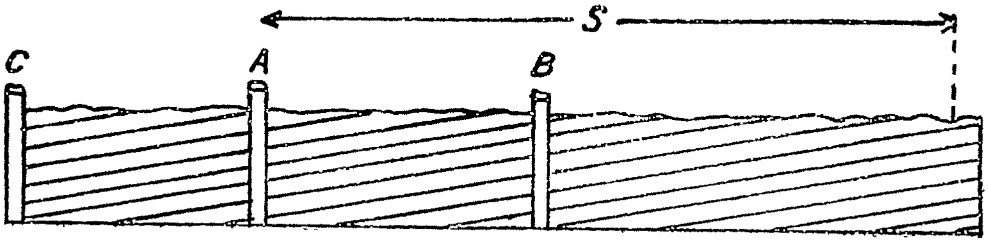

Fig. 2.

Fig. 2. Diagrammatic cross section along dip direction showing the correct distance from well A to another to be sunk. Inclined lines indicate dipping cleavage partings opened and water-bearing. A, B, C: wells within the distance from well A. S · distance from well A to another to be sunk. Top line indicates water levels in the cleavages.

Any other well (B in fig. 2) within a distance of S from well (Fig. 2) on the anterior side of it shall cut the water bearing partings of the first well (A). The first well shall then yield a partial supply out of the last parting and so from all partings overlying it. Two wells must therefore be placed beyond S. On the posterior side in dip direction any other well (C in fig. 2) dug within S from the first well will yield only that water that has remained undrained from the portion of the partings, which are all cut by the first well. A well will yield its full supply beyond S in this direction. S is therefore the distance between two wells on any side of an existing well along dip direction within which new well must not be dug.

Distance between wells along strike direction cannot be specified since water has free movement in the partings. Distant wells may therefore take each other's supply. It is therefore advisable to space two wells along strike direction at as great distance between them as is conveniently possible.

SHAPE OF WELL

Shape of a well should be such that greatest supply should be tapped with minimum excavation. Supply from wells in the Kaladgi rocks depends upon the number of opened cleavage planes tapped. Greatest number of partings are struck through by as great a length along dip direction as possible. A well should therefore have greatest length along dip direction and smallest width along strike direction. This shape is the shape of a 'Trench.'

Wells dug by the public are either circular according to Government type of design or are large square wells. The above advantage of a 'trench' shaped well is not fully realised. Perimeter for perimeter, a trench well in the dip direction would tap more water bearing partings and yield greater supply than a circular or square well. The strata of the Kaladgi series are usually coherent and trench-shaped wells would not collapse earlier than circular or square shaped wells. The 'trench' shape for wells should therefore be adopted by the Government and should be recommended to the cultivators.

In one case only the length of the trench is required not to be necessarily along dip direction, but may be parallel to a permanent stream or river that feeds the well. Courses of the rivers are at several places along the strike of the country rocks. A well will receive water from the bed of the perennial river if it strikes as great a length as possible of a cleavage parting which has its upper end in the bed of the river. In such a case the capacity of the well does not depend upon the number of water-bearing partings tapped, but on the length of such partings, that is the length of the partings striking along the course of the river.

Leaving such cases, which may be useful on banks of rivers and permanent streams, 'trench' wells in Kaladgis should have their length along the dip direction.

THE NECESSITY

What is absolutely needed is to take trials with deep bores in the Kaladgi area for thorough investigations of ground water resources in this arid famine tract. The author strongly believes that considerable ground water wealth underlies the area and large supplies of well water, sub-artesian or artesian water are likely to be available at a large number of sites only if the problem is approached scientifically and systematically. The area at present is a deficit area and is completely neglected. Sincere efforts for investigation are not undertaken by the Government or by the ignorant public, and the author believes that the area suffers from scarcity out of sheer negligence, though large resources of water lie underneath. A systematic scheme for exploration of underground water is, therefore, the urgent need for solving the scarcity problem of this area.

CONCLUSION

Members of the Kaladgi rock series are water-bearing. There are strong reasons to believe that great wealth of well-water and sub-artesian or artesian water underlies the area through ignorance of which the area is being left undeveloped. Systematic exploration is needed.

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No. 13 MAY, 1954

BULLETIN
OF THE
Geological, Mining & Metallurgical Society of India

Society's Suggestions on The Mineral Concession Rules (1949)

CALCUTTA

BULLETIN

OF THE

GEOLOGICAL, MINING AND METALLURGICAL SOCIETY OF INDIA

No. 13 | MAY, 1954

Society's Suggestions on "The Mineral Concession Rules 1949"

The Society informed the India Government on 3-5-54 that the Mineral Concession Rules (1949) amended upto date were proving very unsatisfactory in operation. The Society after due deliberations prepared comments and suggested several amendments which were forwarded to the India Government for their favourable consideration.

Since the framing of the rules during the last several years the Society has been receiving complaints from its members regarding delays in disposing of applications for prospecting license and mining lease. Cases of favouritism in the matter of granting the license or lease have also been reported to the Society.

The Society is of the opinion that the Government of India should invite the State Governments to furnish statements regarding applications for certificate of Approval, Prospecting License and Mining Leases remaining undisposed of and reasons for such delays in these matters.

It may further be noted that the rules should be so worded that there would be no room for vagueness or confusion in interpretation in the method of administering them. Whenever the question of interpretation would arise it is the Centre, which is the framer of the rules ought to give the ruling on the point otherwise the different State Governments might give different interpretations on the same issue.

Unless the working difficulties and grievances of the parties actually engaged in mineral exploration work are removed better condition and clearer atmosphere will not set in the mineral development world and in the opinion of the Society the very object of the Five Year Plans for rapid industrialisation of the Country will thus be defeated.

Society's suggestions for some of the Mineral Concession Rules (1949) which were forwarded to the India Govt., are given below :

Existing Rule	**Society's Suggestion**
le No 7. Application for the certificate ıpproval : An application for the grant or renewal of a certificate of approval shall be submitted to the State Government (through such officer or authority as it may appoint in this behalf), and (every application for the grant of a certificate) shall contain the following particulars :-	(b) The Fellows of the Geological, Mining and Metallurgical Society of India and similar Technical Asssociations should be regarded to have suffiicient qualification for obtaining Certificate of Approval.
(a) (i) If the applicant is an individual, his name, nationality, profession and residence, and (ii) If the applicant is a company, syndicate, partnership or private firm, its name, nature and place of business, place of registration or incorporation ; and) A statement showing the technical qualifications and mining experience of the applicant, and his manager, if any, and such other particulars as may be necessary to satisfy the State Government of the competence of the applicant to hold the certificate.	**Add** : The application for certificate of approval shall be disposed of by the State Government within three months from the date of application and in case it is not disposed of the applicant will have the right to appeal to the Centre.

easons : For granting of Certificate of Approval the procedure should be simplified. Many cases have been kept hanging for years without any action being taken by State Government and the applicants have had no relief of appeal to the Centre.

ule No 10. Renewal of certificate of approval :- A certificate of approval may be renewed on payment of a fee of Rs. 50 if the application for renewal is received within 3 months from the date of expiry of the certificate, After the expiry of three months no renewal shall be granted but an application for a fresh certificate may be made,	Renewal of Certificate of Approval : A certificate of approval shall be renewed on payment of Rs. 50 within three months from the date of receiving application if the application for renewal is made within three months from the date of expiry of the certificate.

Existing Rule	Society's Suggestion
Rule No. 10	After the expiry of three months no renewal shall be granted but an application for a fresh certificate may be made.

Reasons : The holder of a certificate of approval should have a right of renewal.

Rule No 14. Application for prospecting license- An application for a prospecting license shall, in case of land in which the minerals belong to Government, be made to the State Government concerned (through such officer or authority as it may appoint in this behalf) and shall contain the following particulars :- (a) (i) If the applicant is an individual, his name, nationality, profession and residence, and (ii) If the applicant is a company, syndicate, partnership or private firm, its name, nature and place of business, place of registration or incorporation ; (b) The number and date of the notification of the grant or renewal of the certificate of approval of the applicant ; (c) A description, illustrated by a map or plan, showing as accurately as possible the situation boundaries and area of the land in respect of which the license is required ; (d) The period for which the prospecting license is required ; and (e) The mineral or minerals for which the applicant intends to prospect.	Application for prospecting license- An application for a prospecting license shall, in case of land in which the minerals belong to Government, be made to the State Government concerned through such officer or authority as it may appoint in this behalf and shall contain only the following particular :- **Add** : The application for a prospecting license must be disposed of by the State Government within three months from the date of application. In case the application is not disposed of within three months the applicant shall have a right to appeal to the centre.

Reasons : Many applications are kept hanging for a long time sometimes for several years and the applicant has no redress under the existing

Existing Rule **Society's Suggestion**

rules. This question of time limit was discussed at the last meeting of the Mineral Advisory Board held at New Delhi on 7. 8. 53 when a resolution was passed requesting the State Governments to expedite matters. But that resolution remains a pious wish as no action is being taken by the State Government : From our experience we find that the State Governments sometimes keep the applications pending for years. It is therefore highly desirable that a time limit should be imposed on the State Governments to dispose of the applications within a specified period. In the opinion of the Society 3 months time should be considered adequate.

e No 14.	(a) (i), (ii); (b) (d) ; (e) remains unaltered (c) A description, illustrated by a map or plan showing as accurately as possible the situation, boundaries and area of the land in respect of which the license is required; Add : Provided that if the map supplied by the applicant is not complete in all details then the collector may get it done at the cost of the applicant.

sons :—If the map or plan supplied by the applicant is not found to be sufficiently accurate, the application should not be refused on that ground but a correct and detailed map or plan should be prepared by the collector at the cost of the applicant.

e No 17. State Government may grant or refuse a license :- 1) Subject to the provisions of Rule 13, the State Government may grant or refuse the license.	State Government may grant or refuse a license- (1) Subject to the provisions of rule 13 the State Government may grant or refuse the license within 3 months from the date of receipt of application.

Existing Rule	Society's Suggestion
(2) In case of refusal, intimation of the same shall be given to the applicant in writing and the fee paid under rule 15 shall be refunded.	(2) In case of refusal intimation of the same shall be given to the applicant in writing specifying the reasons for such refusal and the fee paid under rule 15 shall be refunded. Provided the applicant shall have the right of appeal to the Centre in case the application is not disposed of within three months from the date of application.

Reasons : As the rule stands today the State Governments can refuse one application without assigning any reason and entertain another application for the same area from another person and the first applicant has no redress.

Sometimes the applications are kept pending for years and in such cases under the present rule the applicant has no redress.

Rule No 18. Priority—If more than one application regarding the same land is received, preference shall be given to the application received first, unless the State Government, for any special reason, and with the prior approval of the Central Government decides to the contrary.	
Amendment made by S. R. O. 1502 of 29th July 1953.	The amendment made by S. R. O. 1502 of 29th July 1953, should be deleted.
Rule 18 shall be renumbered as sub-rule (1) of that rule and to the sub-rule as so renumbered the following proviso shall be added, namely :—	
"Provided that where more than one application in respect of the same land is received on the same day the State Government, after taking into consideration the	

Existing Rule	Society's Suggestion
matters specified in sub-rule (2) and after obtaining the prior approval of the Central Government, may grant the prospecting license to such one of the applicants whom it considers to be the most suitable." "(2) After sub-rule (1) as so renumbered the following rub-rule shall be inserted, namely :— "(2) The matters referred to the proviso to sub-rule (1) shall be following namely :— (i) experience of the applicants in prospecting; (ii) financial soundness and stability of the applicants ; (iii) special knowledge of geology or mining and the technical staff already employed or to be employed for the work."	

Reasons : This may lead to undue favouritism ultimately leading to gross injustic to the first applicant. All holders of certificate of approval should hav equal treatment in the matter of priority of right. Once the certificate of approval was granted to a party his right for mineral concessio should not be abridged by the amendment of the Rules.

23. Conditions of a prospecting license— (1) Every prospecting license shall include the following conditions ; (i) The licensee shall pay such prospecting fee as may be fixed by the State Government, not less than two annas and not more than one rupee per acre of the land covered by the license, for each year, or portion of a year of the period for which the license is granted or renewed. (ii) In the case of minerals other than gold, silver, precious stones or mica, the license shall not confer upon the licensee a right to win or carry away the minerals for commercial purposes ;	Conditions of a prospecti license—(i) Every prospecti license shall include the foll wing conditions :—(ii) (a) an (b) remains unchanged. Add : (c) Provided further th if an application for gra of a mining lease is subm tted, the licensee shall ha a right to win and car away any quantity of t minerals on payment royalty from the areas ov which mining leases ha been applied for.

Existing Rule	Society's Suggestion
Rule No. 23. Provided that he may carry away-	
(a) any quantity within the limits specified in the Second Schedule without any payment; and	
(b) any quantity exceeding such limits, which is incidental to prospecting, on payment of royalty at the rates specified in the First Schedule.	
(iii) In case of gold, silver, precious stones or mica the licensee may carry away any quantity won during the course of prospecting on payment of royalty specified in the First Schedule,	
(iv) The licensee may, with the previous sanction of the State Government, transfer his license or any right (title) or interest therein to a person holding certificate of approval on payment to the State Government of a fee of Rs. 100.	
(v) Save in the case of land over which the licensee is granted a mining lease, he shall, within six months next after the determination of the license or the date of abandonment of the undertaking whichever is earlier, securely plug all bores and fill up or fence all excavations in the land covered by the license.	
(vi) In case of breach by the licensee or his transferee or assignee of any of the conditions of his license, the State Government may cancel the license, or forfeit, in whole or part, the deposit made by the licensee under rule 19.	

Existing Rule	Society's Suggestion
(2) A prospecting license may contain such other conditions, as the State Government may deem fit, including the following :—	
(i) Time and place of payment of the fee;	
(ii) Compensation for damage to land in respect of which license has been granted;	
(iii) Indemnity to Government against the claim of a third party for any damage, injury or disturbance caused to him by the licensee;	
(iv) Restrictions regarding felling of trees on unoccupied and unreserved Government land;	
(v) Restrictions on prospecting operations in an area prohibited by any competent authority;	
(vi) Operations in a reserved or protected forest;	
(vii) Conditions regarding entry on occupied land;	
(viii) Forfeiture of property left after determination of license;	
(ix) Power to take possession of plant, machinery and premises in the event of war or emergency.	

Reasons : Because there are cases where applications for mining lease after prospecting have been kept pending for half a dozen years. If no working is allowed during this period the State will lose royalty and it is also a great hardship on the applicant.

Existing Rule	Society's Suggestion
Rule No. 24. Right to mining lease— On or before the determination of his license, the licensee shall have a right to a mining lease or leases over the whole or part of the area covered by the license, in accordance with the rules in force governing such leases at the time of the grant of the license :	
(Provided that the State Government may for reasons to be recorded in writing and communicated to the licensee, refuse to grant a mining lease to any such licensee). Added by Notification No. M. II-159(10), dated 7-11-1951.	Provision added by Notification No. M, II-159(10), dated 7-11-1951 should be deleted.

Reasons : The amendments should be deleted, because this will empower the State Governments to refuse the right to mining lease on any pretext.

Rule No. 27. Application for mining lease— An application for a mining lease shall, in case of land in which the minerals belong to Government, be made to the State Government concerned (through such officer or authority as it may appoint in this behalf) and shall contain the following particulars :- (a) (i) If the applicant is an individual, his name, nationality, profession and residence, and (ii) if the applicant is a company, syndicate, partnership or private firm, its name, nature and place of business and place of registration or incorporation ; (b) The number and date of the notification of the grant or renewal of certificate of approval of the applicant ;	(a), (b), (d), (e), (f), (g), (h) remain unaltered.

Existing Rule	Society's Suggestion
(c) A description, illustrated by a map or plan, showing accurately as possible the situation, boundaries and area of the land in respect of which the lease is required ;	(c) A description, illustrated by a map or plan, showing as accurately as possible the situation, boundaries and area of the land in respect of which the lease is required. Add-Provided that if the State Government requires a map on a larger scale, the applicant will either submit a map himself or at his request the Collector may get it done at the cost of the applicant.
(d) The mineral or minerals which the applicant intends to mine ;	
(e) The area and minerals within the jurisdiction of the State Government for which the applicant or any person joint in interest with him already holds a mining lease ;	
(f) If the applicant holds a prospecting license for the area applied for, the number and date of such license ;	
(g) The period for which the lease is required ; and	
(h) The industry, if any, which the applicant proposes to develop, and the location of such industry.	
Rule No. 28. Application fee— (1) The application shall be accompanied by a fee of Rs. 200. If the State Government refuses to grant the lease applied for or if the applicant refuses to accept the lease on account of any special condition imposed therein under sub-rule (3) of rule 41, the fee shall be refunded.	
(2) When an application for a mining lease is refused by the State Government, intimation of the refusal shall be given to the applicant in writing.	(2) When an application for a mining lease is refused by a State Government, intimation of the refusal shall be given to the applicant in writing specifying the reasons for such refusal.

Reasons : Otherwise the applicant is hampered in stating grounds for appeal.

Existing Rule	**Society's Suggestion**
Rule No. 32. Priority—If more than one application regarding the same land is received, preference shall be given to the application received first, unless the State Government, for any special reason, and with the prior approval of the Central Government decides to the contrary.	
Amendment made by S. R. O. 1502 of 29th July 1953 : Rule 32 shall be remembered as sub-rule (1) of that rule and to the sub-rule as so renumbered the following proviso shall be inserted, namely :- "Provided that where more than one application in respect of the same land is received on the same day, the State Government, after taking into consideration the matters specified in sub-rule (2) and after obtaining the prior approval of the Central Government, may grant the mining lease to such one of the applicants whom it considers to be the most suitable" After sub-rule (1) as so renumbered the following sub-rule shall be inserted, namely : "(2) The matters referred to in the proviso to sub-rule (1) shall be the following namely :- (1) Experience of the applicants in mining, (ii) Financial soundness and stability of the applicants, (iii) Special knowledge of Geology or mining and technical staff already employed or to be employed for the work."	The amendment made by S.R.O. 1502 on 29th July, 1953, should be deleted.

Reasons : The priority should always be given to the first applicant. The date and time of receipt of application should be recorded on the application as this will eliminate favouritism and corrupt practices as provided for under rule 16. The original Rule No. 32 is quite adequate for its purpose.

Existing Rule	Society's Suggestion
Rule No. 57. Application for review : (1) Any person aggrieved by an order of a State Government- (i) refusing to grant a certificate of approval, prospecting license or mining lease ; (i-A) refusing to renew a certificate of approval ; (ii) cancelling a prospecting license or mining lease ; (iii) refusing to permit transfer of a prospecting license under rule-23 (iv) or a mining lease under rule 37 may, within two months of the date of such order, apply to the Central Government for reviewing the same. (2) An application for review under sub-rule (1) may be admitted after the period of limitation prescribed therein when the applicant satisfies the Central Government that he had sufficient cause for not making the application with the said period.	Application for review :- (1) Any person aggrieved by any action of the State Government in the administration of mineral concession rules shall have a right of appeal to the Central Government within two months from the date of cause of action for reviewing the same.

Reasons : It is highly desirable that a party should have a right of appeal on any grievance against the State Government. Because the grievances of parties may not be restricted only to the points mentioned under (i), (i A) (ii) and (iii) of Rule 57 (1),

Existing Rule	Society's Suggestion
Rule No. 66. Preference as between applicants for prospecting license and mining lease : Where applications for both a prospecting license and a mining lease for the same land are received on the same day the application for a mining lease shall not have any preference over the application for a	Where applications for both a prospecting license and a mining lease for the same land are received on the same day the application first received either for prospecting license or for mining lease

Existing Rule	**Society's Suggestion**
prospecting license except in the case of an area which was held and worked under a mining lease previously.	should have preference unless the State Government for any special reasons and with the prior approval of the Central Government decides to the contrary.

Reasons : Priority of application should always be respected.

Regarding the administrative forms in connection with the Certificate of Approval, Renewal of Certificate of Approval, Prospecting license and Mining lease etc. it may be pointed out that these forms appear to be very exhaustive and complicated. It is desirable that much simpler forms may be introduced. Moreover endeavour should be made to make the forms uniform for all the States as the parties working the same mineral deposits occurring in the adjoining States are put to considerable difficulty due to the diverse and peculiar nature of the forms of the different States.

The forms should be prescribed by the Centre and should be as simple as possible and should be applicable uniformly throughout all the States.

No. 14 SEPTEMBER, 1955

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BULLETIN
OF THE
Geological, Mining & Metallurgical Society of India

PART I.

Electro-Conductivity Titrations of Mixtures of Sodium Carbonate and Sodium Bicarbonate

By
C. P. Dhamaney

PART II.

Electro-Conductometric Titrations of Mixtures of Tartarate and Sodium Bitartarate.

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No. 14 | September, 1955

PART I

Electro-Conductivity Titrations of Mixtures of Sodium Carbonate and Sodium Bicarbonate*

By

C. P. Dhamaney

For the estimation of Sodium carbonate (Na_2CO_3) in presence of Sodium bicarbonate ($NaHCO_3$) various titration methods have been suggested in which internal indicators such as Phenolphthalein or Red-cresol along with Methylorange are used. The acid required to change the colour of Phenolphthalein or Red-cresol is equivalent to half the carbonate owing to its conversion to bicarbonate upto this stage whilst the additional volume of the acid required to change the colour of Methylorange is equivalent to half the carbonate plus the original bicarbonate. But this indicator method along with others is not useful in case of coloured mixtures met with in industry, such as cooking liquor, black liquor, washed pulp, and leach black ash.

Hoffman (Paper Trade, J. 84.201-205, 1927) has suggested the determination of Soda in such liquors from their specific conductivities refering to a graph of specific conductivities plotted against known concentrations of pure Sodium carbonate under the same conditions.

Reference may be made to experimental work carried out by Kalthoff (Z. anorg. chem. 1920, 112, 156) on Conductometric titration of H_2CO_3 with NaOH.

The object of this work was to see if Electro-conductometric titration could be carried out successfully for mixtures of Sodium carbonate and Sodium bicarbonate. Since the specific electric conductivity of Sodium-bicarbonate is lower than that of Sodium carbonate and Sodium chloride as determined by Kohlrausch and Hollner (Leituer mogen der Electrolyte, p. 152-153), the electro-conductivity curve for Sodium carbonate against HCl should show a break at complete conversion of Na_2CO_3 to $NaHCO_3$ by HCl. Our experiments show such a break in the case of pure Sodium carbonate solutions as well as mixtures of Na_2CO_3 and $NaHCO_3$ of various concentrations.

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*Read before the Society on 4. 8. 55.

EXPERIMENTAL

Pure Merck's Sodium carbonate (Na_2CO_3, anhydrous) and Sodium bicarbonate ($NaHCO_3$) and Hydrochloric acid (HCl) were used. They were standardised with Oxalic acid (Pure, crystalline) using Sodium Hydroxide solution as an intermediate. Electric conductivities were determined in an electrolytic cell of Jena glass (with platinized electrodes kept at fixed distance) by means of a Post office box accompanied by a vacuum tube oscillator for source of current and a vacuum tube amplifier for detecting circuit ; the apparatus was sensitive to 0.1 ohm.

20 c.c. of the alkali were introduced in the cell placed in a water thermostat at 34°C. and 0.1 c.c. of HCl having nearly ten times the normality of the alkali was introduced at a time to avoid dilution. The cell was shaken gently taking care not to disturb the electrodes and the reading on the bridge was taken after every five minutes. Electro-conductivity titrations of one standard solution of Sodium carbonate and one standard solution of Sodium bicarbonate are shown in Table I, while those of the mixtures of various concentrations are shown in Table II. The comparison of the volumes of HCl required for neutralization from the electro-conductivity curves of the mixtures shown in graphs A, B and C with those calculated from the normalities are shown in tables I (b) and II (b).

TABLE I (a)

A = Na_2CO_3 (0.2697N) against 2.976N HCl.
B = $NaHCO_3$ (0.2545N) against 2.976N HCl.

No. of c.c. HCl added.	Resistance A	Resistance B
0.0c.c.	167 Ohms	168 Ohms
0.1	165 ,,	166 ,,
0.2	163 ,,	163 ,,
0.3	161 ,,	160 ,,
0.4	159 ,,	157 ,,
0.5	158 ,,	154 ,,
0.6	156 ,,	151 ,,
0.7	154 ,,	149 ,,
0.8	153 ,,	147 ,,
0.9	150 ,,	145 ,,
1.0	148 ,,	143 ,,
1.1	147 ,,	140 ,,
1.2	146 ,,	137 ,,
1.3	145 ,,	
1.4	144 ,,	133 ,,
1.5	143 ,,	130 ,,
1.6	142 ,,	127 ,,
1.7	140 ,,	124 ,,
1.8	137 ,,	111 ,,
1.9	130 ,,	95 ,,
2.0	110 ,,	
2.1	93 ,,	76 ,,
2.2	83 ,,	
2.3	76 ,,	63 ,,
2.4	71 ,,	

TABLE I (b)

Solution No.	c c. of HCl required for complete neutralization.	
	From EC curve	Calculated from normality.
A	1.8	1.81
B	1.7	1.71

The results of the solution of Sodium carbonate and that of Sodium bicarbonate are plotted in graphs A and B respectively. In graph A there is a break at 0.8 c.c, while there is no break in case of graph B.

TABLE II (a)

20c.c. of mixtures of exact volumes of Na_2CO_3 and $NaHCO_3$ of following normalities against HCl used.

A. Na_2CO_3 0.0899N and $NaHCO_3$ 0.084825N against HCl 0.947N
B. Na_2CO_3 0.1798N and $NaHCO_3$ 0.16965 N against HCl 1.984N
C. Na_2CO_3 0.2697N and $NaHCO_3$ 0.2545 N against HCl 2.976N
D. Na_2CO_3 0.3596N and $NaHCO_3$ 0.3393 N against HCl 3.866N
E. Na_2CO_3 0.3596N (75%) $NaHCO_3$ 0.3393 N (25%) HCl 3.866N

c.c. of HCl.	Resistance in ohms of Mixtures.				
	A	B	C	D	E
0.0c.c.	420	231	165	133	130
0.1	416	230	161	130	128
0.2	414	227	160	127	
0.3	412	225	159	124	125
0.4	410	225	157	124	123
0.5	405	220	152	120	123
0.6	403	220	149	117	122
0.7	400	217	141	115	117
0.8	400	214	147	114	115
0.9	397	212	147	144	113
1.0	390	207	144	111	111
1.1		206	144	109	110
1.2	386	204	143	107	109
1.3		203	142	105	103
1.4	381	200	141	104	103
1.5	375	198	139	103	
1.6	369	196	137	102	103
1.7	363		135	100	103
1.8	357	194	133	98	95
1.9	353	189	128	87	84
2.0	317	177	111	73	72
2.1		147	93	66	
2.2	244			60	58
2.3		119	81	53	
2.4	207				50

The above results are plotted in graph C.

TABLE II (b)

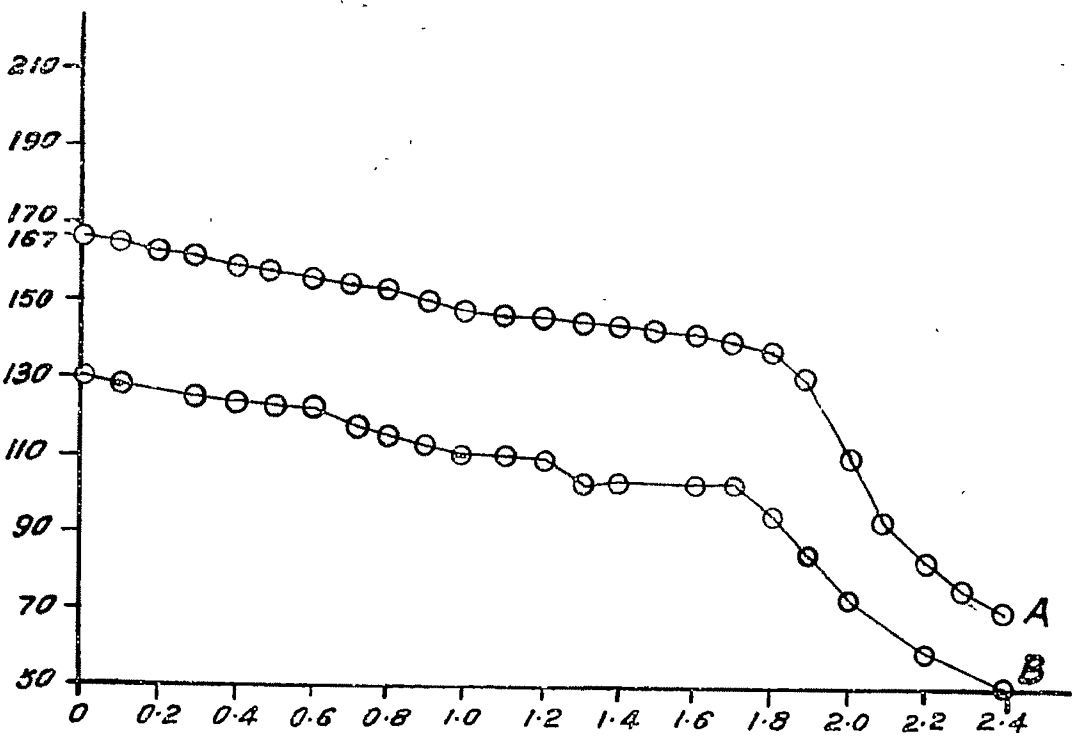
Solution No.	Total No. of HCl for 20c.c. of Mixture of Na_2CO_3 & $NaHCO_3$		No. of c.c. of HCl for Na_2CO_3		No. of HCl for $NaHCO_3$	
	E.C. Curve	Calc.	From E. C. Curve	Calc.	From E. C. Curve	Calculated
A	1.9	1.845	0.9	0.949	0.9	0.895
B	1.8	1.76	0.9	0.9	0.9	0.85
C	1.8	1.76	0.9	0.9	0.9	0.85
D	1.8	1.807	0.9	0.9	0.9	0.85
E	1.7	1.83	1.25	1.39	0.5	0.439

DISCUSSION OF RESULTS

From graph A we see that in the case of Sodium-carbonate solution, there is a break in the curve at 0.8c.c. of HCl and the neutral point comes at 1.8c.c. This shows that the break does not occur exactly at half of the neutral point as expected. In case of mixtures, the first break in the curve occurs at 0.4c.c. in all 50 : 50 cases and there is a second break which is also conspicuous at 0.9c.c. This second break was never expected since the titration curve of Sodium bicarbonate is without any break. This second break is exactly the neutral point of Na_2CO_3. Since we are adding HCl nearly ten times stronger than the alkali, determination of exact intermediate break is not possible. If we take mean of the point at the break and the succeeding point the results tally with the calculated ones as shown in table II (a). In our opinion the electro-conductivity titrations can be safely followed for the commercial analysis of mixtures of Sodium-carbonate and Sodium bicarbonate for which indicators are of no use.

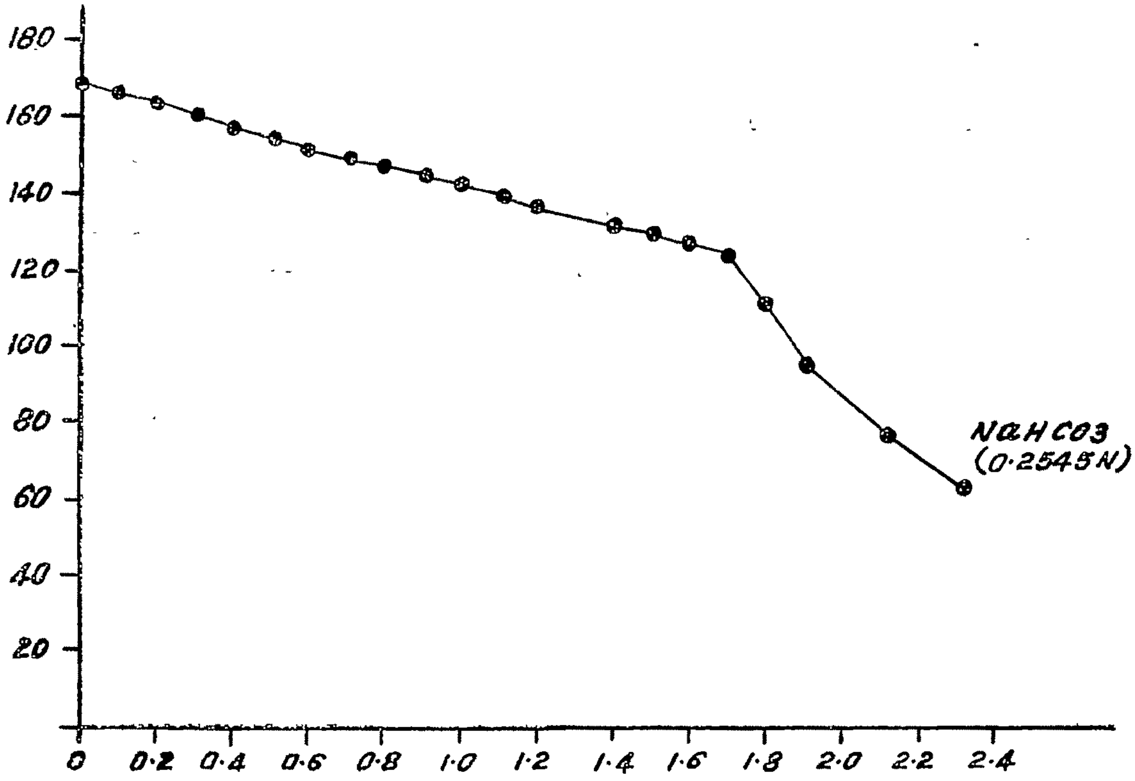
SUMMARY.

Electro-conductivity titrations of Sodium carbonate, Sodium bicarbonate and their mixtures in various proportions have been performed with HCl of nearly of ten times the normality of the alkali. In addition to the neutral point, the titration curves plotted for Sodium carbonate show a break at a point corresponding nearly to half the quantity of Sodium carbonate. There is no such break in the case of Sodium bicarbonate curves. In case of mixtures there are two breaks, one corresponding nearly to half the quantity and the other corresponding to the total quantity of Sodium carbonate. This method can be well used for the commercial analysis of coloured mixtures of Sodium carbonate and Sodium bicarbonate.

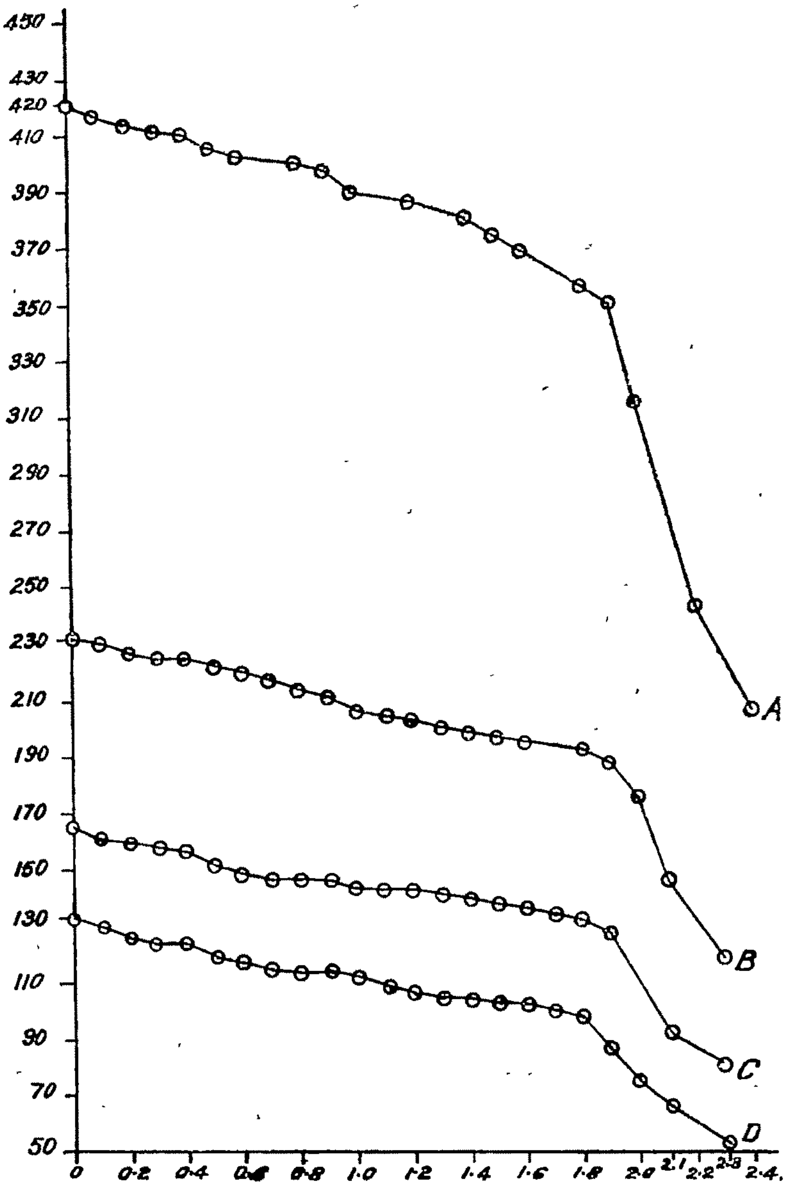


GRAPH A

B. MiX : $NaHCO_3$ (0·3393N) + Na_2CO_3 (0·3596N) A. Na_2CO_3 (0·2697N)



GRAPH B



GRAPH C

A. MIX : Na_2CO_3 (0·0899N)
$NaHCO_3$ (0·084825N)

B. MIX : Na_2CO_3 (0·1798N)
$NaHCO_3$ (0·16965N)

C. MIX : Na_2CO_3 (0·2697N)
$NaHCO_3$ (0·2545N)

D MiX : Na_2CO_3 (0·3596N)
$NaHCO_3$ (0·3393N)

PART II

Electro-Conductometric Titrations of Mixtures of Sodium Tartarate and Sodium Bitartarate.

By
C. P. Dhamaney

The indicator method along with others is not useful in case of coloured mixtures, met with in industry, such as cooking liquor, black liquor, washed pulp, and leached black ash. Hence the object of this work was to see if electro-conductometric titration could be carried out successfully for mixtures of sodium tartarate and sodium bitartarate. Since the specific electric conductivity of sodium bicarbonate is lower than that of sodium carbonate and sodium chloride, as determined by Kohlrausch and Hollner (Leituer mogen der Electrolyte, p 152-153) and the dissociation constants at two stages different, the electric conductivity curve for sodium carbonate against hydrochloric acid should show a break at complete conversion of sodium carbonate to sodium bicarbonate by hydrochloric acid. It has been experimentally shown that such a break appears in the case of pure sodium carbonate and sodium tartarate. The help of this break has been taken to titrate electrometrically, mixtures of sodium tartarate and sodium bitartarate.

The apparatus used for determining the electrical conductivities of the solutions is shown in the fig. 1 and consisted of the following parts ;

(1) Source of current.
(2) P. O. Box.
(3) Amplifier.
(4) Head Telephones.

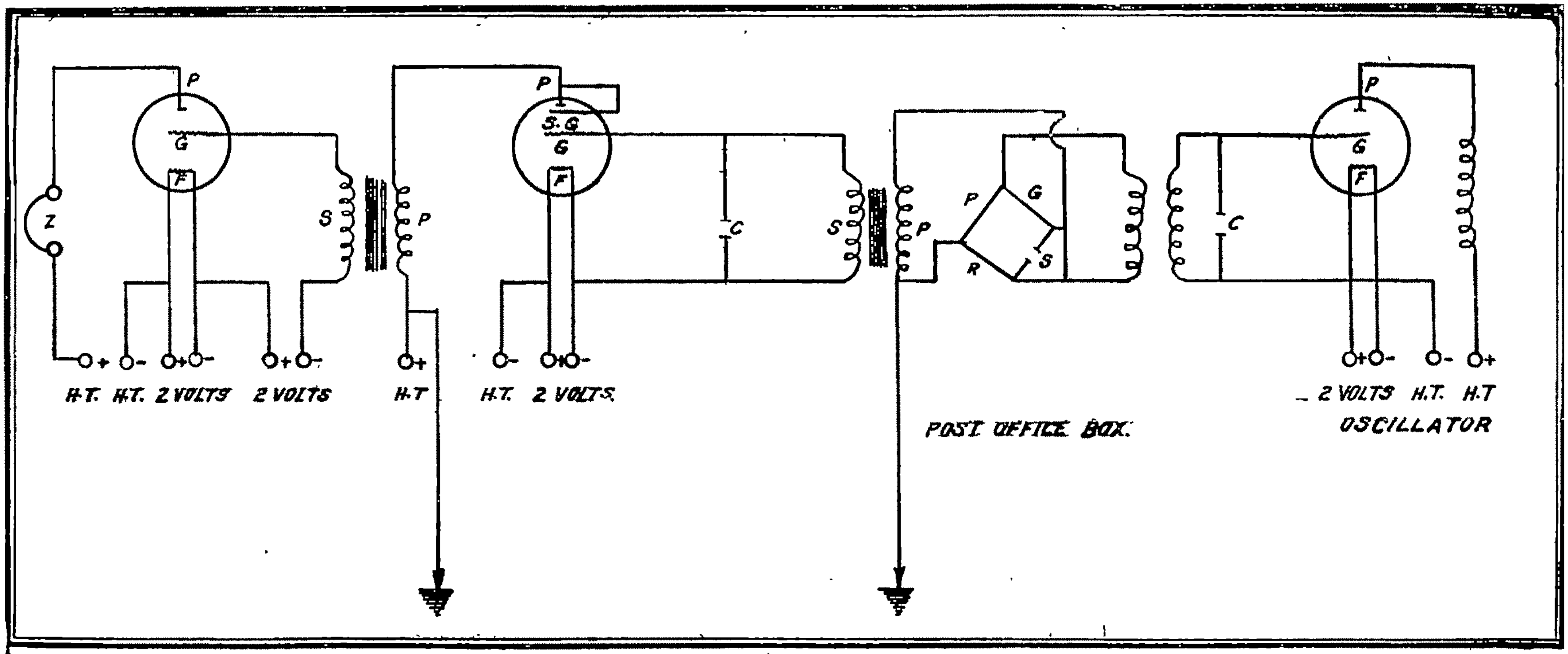
Stock solutions of Merck's pure sodium tartarate (anhydrous) and sodium bitartarate were prepared. 20 c.c. of each solution were placed in the conductivity cell placed in the water thermostat at 34° C+0.1° C. General connections of the apparatus were made as shown in the diagram and the resistance of the solution was found by locating the null-point on the bridge. After taking the initial reading of the solution on the bridge 0.1.c.c. of hydrochloric acid having ten times the normality of the alkali was introduced at a time. To avoid errors due to dilution such a concentrated hydrochloric acid was used. The cell was shaken quite gently just to facilitate the rapid intermixture and the reading on the bridge was taken after every five minutes at the constant temperature.

The colour indicator titrations, are characterised by a total dependence on one single point at which the colour changes. But on the contrary conductometric titrations are typified by series of points, the number of which can be controlled as desired. After going through the experimental work the graph lines are drawn representing the results. Therefore the individual curves are considered to throw light on certain features necessary to understand the subject. Hence it is advisable to start with single titrations of sodium tartarate and sodium bitartarate against hydrochloric acid separately.

From the *Graph 1* it will be seen that titration of sodium tartarate shows two breaks, one at 0.8 and the other at 1.6 c.c. of hydrochloric acid, showing thereby that the first break occurs exactly at half of the neutral point indicating consumption of half the sodium tartarate and the conductivity of the solution of the salt of weak acid as in sodium bitartarate changes very little, on addition of strong acid till all the weak acid is consumed and at this point there will be a marked jump in the conductivity as soon as very little quantity of strong acid is added as seen from the *Graph 1.*

In the case of mixtures of sodium tartarate and sodium bitartarate, *Graph 2* shows that the first break comes at 0.4 c.c. and the last break showing null point is at 1.5c.c. HCl in all 50:50% cases. In the case of Mixtures 40:60, 60:40 & 80:20 where the percentage compositions are changed in order to examine the accuracy of the method, it is observed that the first break is at 0.3, 0.5 and 0.6 HCl, respectively the last point is at 1.5c.c. of hydrochloric acid in all cases but in the case of mixtures the first break is not very sharp, perhaps due to the very little difference of dissociation constant.

From the above it is evident that the conductometric titrations could easily and safely be followed for the commercial analysis of coloured mixtures of sodium tartarate and sodium bitartarate for which indicators are of no use.


Z
P
G
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P
S.G
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F
C
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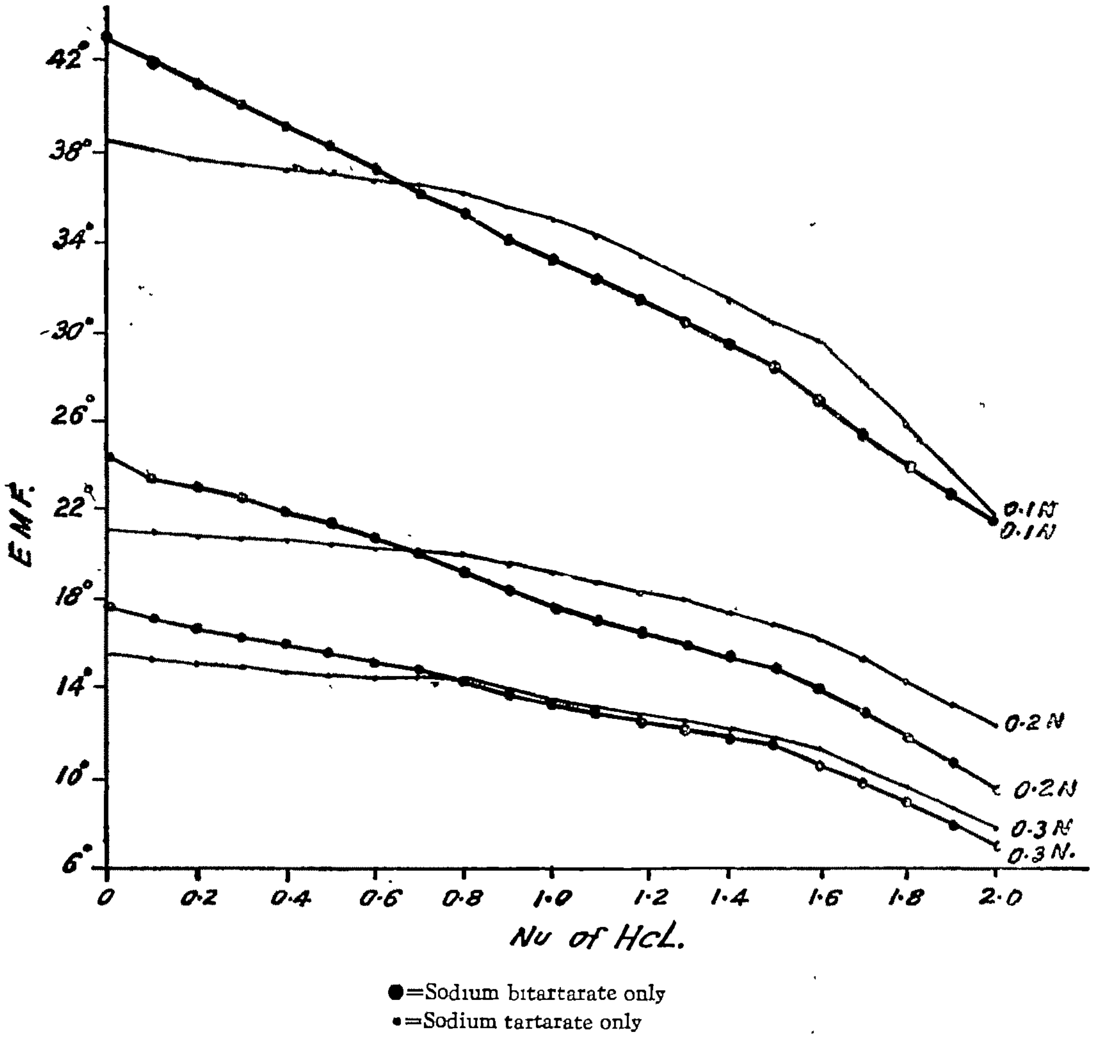
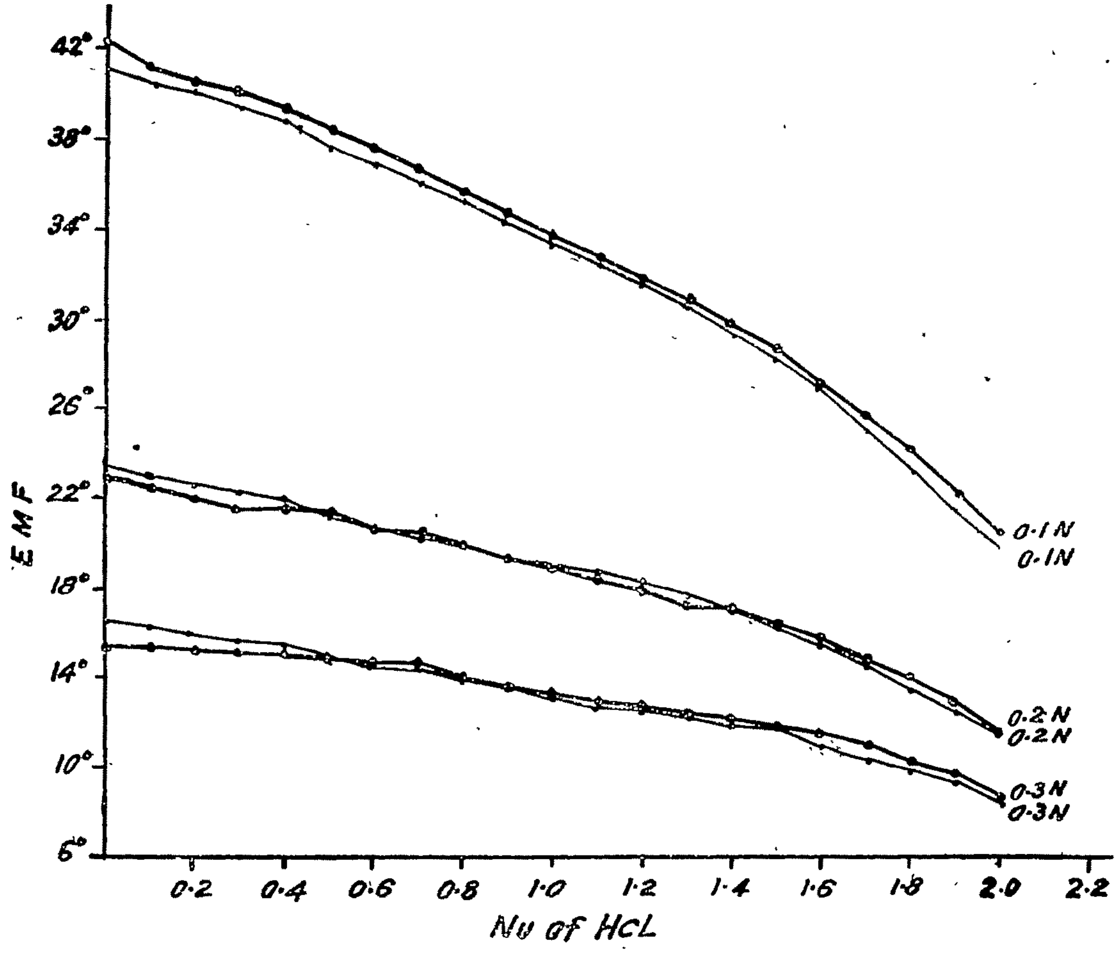
P
G
R
S
C
P
G
F
H.T. H.T. 2 VOLTS 2 VOLTS
H.T
H.T. 2 VOLTS
POST OFFICE BOX.
– 2 VOLTS H.T. H.T
OSCILLATOR

Fig. 1


EMF.
42°
38°
34°
30°
26°
22°
18°
14°
10°
6°
0
0·2
0·4
0·6
0·8
1·0
1·2
1·4
1·6
1·8
2·0
Nu of HcL.
0·1N
0·1N
0·2N
0·2N
0·3N
0·3N.
●=Sodium bitartarate only
•=Sodium tartarate only

GRAPH 1



⊕ = Mix. of Sodium tartarate and Sodium bi tartarate

0 1N	40%	60%
0 2N	60%	40%
0·3N	80%	20%

● = 0·IN-0·3N 50% 50%

GRAPH 2

OF THE

GEOLOGICAL, MINING AND METALLURGICAL SOCIETY OF INDIA

No. 15

JANUARY
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The Site illustration of Iron and Steel and Allied Ferro-Alloy Industry with Reference to Sambalpur, Orissa 1
(With Fig. 1)
By
Ashoka Singh

Office :—Geology Department, Presidency College, Calcutta

BULLETIN
OF THE
GEOLOGICAL, MINING AND METALLURGICAL
SOCIETY OF INDIA

No. 15 January, 1956

The Site Illustration of Iron and Steel and Allied Ferro-Alloy Industry with Reference to Sambalpur, Orissa*

(With Fig. 1)

By

ASHOKA SINGH

Sambalpur-Site in Orissa has the natural resources for feeding a steel and iron plant of one and half million ton annual capacity and in the future it can be raised to two million tons. It can most economically exploit the extensive deposits of high quality iron ore reserves of at least 2000 million tons from Keonjhar, Bonai, South Singhbhum and small deposits of Sambalpur district too. The extensive survey can rightly claim upto 3000 million tons. The Hydro-electric power can be obtained from the Hirakud Dam. The demand of coal can be met from the Talchir, Hingir and Rampur coalfields. The manganese, to which the great iron and steel industry of the world looks for and lacks the most, is best situated in chemical composition, physical property and geographical position to this site. The close chromite deposits of Orissa, with manganese will encourage the great Ferro-chrome and Ferro-manganese industry. There are also very good resources of 1 million tons of flux. There are also scattered deposits of refractory material in the district itself and in the near vicinity too. (Fig. 1).

INTRODUCTION

The great iron ore districts of Bihar and Orissa have similar Archaean-shield foundation as that of Canada, U. S. A. and North Scandinavia. Haematite of Bihar and Orissa is better in quality and quantity than every deposit of its kind in the whole world, even than those of Lake Superior, U.S.A. and Minas Geraes in Brazil. The only exploitation of these vast deposits is by Tatas, and Bengal Iron and Steel Company, whereas the most of the regions are not exploited. So the immediate development is most natural and awaited.

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*Read before the Society on 29. 6. 54

The small scale iron and steel industry of Sambalpur is very old. Dr. Short, hundred years ago, described the process for obtaining iron from iron-stone. No flux was used and the ore was smelted by charcoal. He described the old furnaces too, employed in the industry.

IRON ORES

In Keonjhar, Bonai and South Singhbhum are lying the main resources, and also half a score of scattered small deposits in the Sambalpur district itself. The percentage of iron varies from 57% to 67% in deposits of South Singhbhum, Keonjhar and Bonai. The immediate exploitation can be started from South Singhbhum, Keonjhar and Bonai iron belt. The ore reserves estimate to 885 million tons of iron ores.

South Singhbhum—The Southernmost part of the Singhbhum district of Bihar has 1047,063,000 tons of iron ores as estimated by H. Cecil Jones. Though the Tatas have got some property here, yet this iron and steel industry under discussion can exploit the following resources of 452,440,000 tons.

	13,200,000	tons.	or	13.2 m.	tons
Irpani Bura	211,200,000	„	„	211.2 m.	„
	146,300,000	„	„	146.3 m.	„
Sasangda	112,860,000	„	„	112.86 m	„
	28,160,000	„	„	28.16 m.	„
Tabia	8,800,000	„	„	8.8 m.	„
	22,800,000	„	„	22.8 m.	„
Total—	452,440,000	„	„	452.44 m.	„

Keonjhar—In Keonjhar state 987,568,000 tons of iron ore were estimated by H. C. Jones and 1483,250,000 tons are estimated by Dr. Krishnan. It is about 90 miles from Sambalpur. The ore from the South Sambalpur, Keonjhar, Bonai iron border deposits comes to the following estimates.

Bonai—The total reserve of this district comes to 648,106,000 tons of iron ore, Therefore the sharing reserves from S. Sambalpur, Keonjhar and Bonai border deposits estimate as follows.

Singhbhum Keonjhar Bonai iron belts	79200,000	tons
Sanagali	79200,000	„
North Samlair	52800,009	„
Samlaibar Pahar	26400,000	„
Bichikhar	6600,000	„
	79200,000	„
Dhadrahar	21120,000	„
	344,520,000	tons.

Iron ore reserves of Sambalpur district—The deposits are scattered here and there in the district and need extensive survey before exploitation. These occur in small linear ridges or Dungris, or sometimes occurring as scattered lateritic debris on hill slopes. The ore varies in composition from hæmatite-quartz-limonitic rocks, to nearly pure hæmatite with traces of pyrolusite, psilomelane and wad. Iron percentage ranges from 55% to 60% with 0·76% Mn. and 0·31%P. The Lohakhand and Akharadand, about 20 miles from Sambalpur can be exploited as they contain 5 million tons and 15 million tons of iron ores respectively. They lie within 10 miles to the railway line connecting Jharsugra and Sambalpur. The other reserves can well be exploited, and have 10 million tons of iron ores and about 15 miles from S. E. Railway line (Fig. 1).

COAL RESERVES

Coal Resources—The Rampur or Ib river coalfields, Hingir coal-fields and Talchir coalfields can feed the needs of iron steel industry, in case the method of iron smelting with non-coking coals is introduced.

Rampur Coalfields are nearly 22 miles N. N. W. from Sambalpur In these coalfields there are several coal seams, specially in these, the seams worked out in the Ib river colliery are of good qualities, though high in moisture, with 6600 calories as calorific value. The analysis from the Rampur Coal Company by B. C. Roy reveals Moisture, 2·5% ; Volatile matter, 30.25%; Fixed carbon, 51.25%; and Ash, 16%. Fox estimated 20 sq. miles Rampur seam, westward from Lamtibahal nala and north of Lilari nala, containing 100 million tons of coal reserves within a depth of 600 ft.

Hingir Coalfield—It is lying not more than 35 miles from Sambalpur and not far from the Railway line, and the exploitation will be of great value as it is about 40 sq. miles. One coal seam of fair quality, 45 ft. thick has already been known. A 2 ft.

thick coal seam, 30 to 35 ft. below the surface has been recently reported from the region between Gochhapua and Katrangia in Ganjam district.

Talchir Coalfields—There are two workable coal seams in this area of about 11 sq. miles near Talchir. The seams are, the top seam about 9 ft. thick and the bottom seam, 13 ft. in thickness. The coals of this field are dull and frequently shale-like. Though relatively low in ash, the coal contains about 10% moisture ; certain sections of these seams are of good quality, their calorific value being between 6000 and 7000 calories.

Flux—The extensive deposits of limestone, high in magnesia and iron percentage are found in Gangpur State and Padampur in Sambalpur district, with low silica, and alumina percentage.

Gangpur State—The extensive deposits of limestone are found in this State and the continuation of these beds goes upto Sambalpur. In Sambalpur, only a small portion of these beds occurs, and outcrop is three furlongs along strike and one furlong across strike and workable depth of 50 ft. in a flat country. On the basis of 12·5 cu. ft. per ton, 5 million tons are available in Sambalpur side only. It contains about 21% and 1% of MgO. and Fe_2O_3 respectively. These deposits are only lying 6 miles of Dhatura Station of S. E. Ry..

Padampur—Limestone and shale occur between Launsara and Tamdei, south of Padampur and 10 miles south of nearest railway station, Jamga. Within the stretch of river bed examined, there are four limestone horizons, their width of outcrop, across the strike ranging 50 ft. to maximum of about 3 furlongs. On analysis, limestones from bands lying between Tamdei and Padampur are found to contain high% of MgO ; in horizon II, 17·9% of MgO ; and 0·80% of Fe_2O_3 ; in horizon III, 14·12% of MgO. These reserves are extensive and can easily meet the demand of flux of iron and steel industry.

MANGANESE ORES

The Kutingi deposit (19°05′ : 83° : 10′) near Rayagada Railway Station on the S. E. Railway has 406,000 tons of Manganese ores The deposits of Singhbhum can also be exploited accordingly, with the increasing demand of ferro-manganese industry. With the more extended application of hydro-electric power, there could be a greater demand for domestic ores, particularly the high silica manganese, provided a satisfactory market could be created for such product Sambalpur is best situated with respect to assembling of raw materials and selling products, and is also near water-power site of Hirakud. The price of our ore containing manganese, phosphorus and silica is quite cheap.

CHROMITE

The chromite from Singhbhum can also meet the demand of ferro-chrome industry of Sambalpur. The production of that locality is 5000 tons approximately. The ferro-alloy plant will have the same facility as in Canada, Norway, Sweden and France.

Labour & Economics—The cheap labour will enhance the progress of exploitation of the essential minerals for the iron and steel industry. The form of the iron ore-bodies favours the easy mining and mostly open surface cut mining, in large scale. The ore is of high quality. The tonnage is also large, and author is of the opinion that it may be favourably compared with the ore of any part of the world. The topography is favourable for the transport of the ores to the smelters.

Transport—All these minerals are already existing near the transportation centre and can be commercially mined at low cost (Fig. 1). Sambalpur is connected with the main railway through loop line from Jharsugada. Sambalpur is also connected by a motorable road from Talchir, and the railway line joining both the districts is under consideration.

The transportation cost can be more economised by setting up the ore dressing plant at the mining sites. The scattered ore deposits can be connected through "ropeways" to the main ore dressing plant. Then the dressed ore transportation by railways will be more economical. The extension of the present railways upto the southern most extremity will be very wise and economical.

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BULLETIN
OF THE
GEOLOGICAL, MINING AND METALLURGICAL
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No. 16 March, 1956

A Plan for Establishing Aluminium Industry in Central India near Rihand Dam, Uttar Pradesh.*

BY

BALRAM K. MAHENDRA.

Aluminium is the 'Magic Metal' of 20th century and it may be easily called the 'Essential Metal' of India because of the scarcity of other non-ferrous metals.

Every sort of enterprise or industry depends upon the availability of essential raw materials for its success. In making aluminium, the importance of raw materials can not be over emphasised. It takes about 7 tons of raw materials, plus electric energy equivalent to 16 tons of coal, to make 1 ton of aluminium. The basic raw material of aluminium is the ore bauxite, approximately four tons of which must be treated by electro-chemical processes to produce one ton of aluminium.

BAUXITE DEPOSITS OF AMARKANTAK PLATEAU

The prominent deposits of bauxite in Central India occur on the Amarkantak plateau near Bilaspur and extend both in the northern and southern division in the Rewa territory to Vindhya Pradesh. The deposits on the Maikala Hill range, southern division, were found to be very extensive and richer in alumina than those of the northern division. The Sirgo, Andhi, and Jhalawar Hill occurrences, between latitudes 24° 20′ and 24° 30′, occupy a very limited area and scattered patches on the Vindhyan uplands of north Rewa. In the eastern part of Maikala range there is a plateau extending for miles in a north-west to south-east direction. The Village of Amarkantak from which the plateau derives its name, forms the extreme eastern part of the Maikala range of hills. Amarkantak is famous as source of Narbada river and is one of the beautiful spots in India.

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*Read before the Society on 14. 3. 55

The plateau of Amarkantak within the Rewa territory occupies an area of 800 sq. miles, the major portion of which lies in Sohagpur Tehsil. Bauxite of good quality occurs only in the southern part near Amarkantak and Umagohan and in the ranges of hills north of Narbada river between longitudes 81° 30′ and 81° 45′.

The area is an open upland country at a height of about 3,500 ft. above sea level. To the west are the chief highlands such as those of Amarkantak plateau and Rajmergarh. The mountains are of relict type, that is, they have been carved out by weathering agencies. The plateau forms a water-shed between the westerly, easterly and northerly drainage of Central India Out of the heart of this plateau, valleys are cut by the Narbada, Johilla and Sonebhadra, the three important rivers which rank among the greatest streams of Central India. The plateau to the east of Maikala range is drained by the Son, Amanala and Mati Nala etc. The river Son flows northwards and north-eastwards and ultimately joins the Ganges. Johilla, Kewai, Kunak, Rehr etc., are its tributaries.

The geological formations of the eastern part of Maikala range consist of Gneisses, Lameta beds, Trap and Laterite. The geological succession as studied in the area is given below :

Name of the rock formation.	Approximate thickness.	Mode of formation.	Principal exposures.	Age
Laterite with bauxite.	30 to 40 ft.	Secondary origin.	Amarkantak, Miria, and Damgarh.	Tertiary.
Plateau Basalt with ash beds & inter-trappeans	1000 ft.	Volcanic.	Amarkantak scarp	Upper Cretaceous-Eocene.
Calcareous sandstone.	70 ft.	Lacustrine	West of Pakaria.	Cretaceous (middle).
Siliceous Limestone.	50 ft.	Lacustrine.	West of Pakaria.	Middle Cretaceous,
Unconformity.				Unconformity.
Bundelkhand Gneiss ?	Intrusive in the older Gneisses & Schists	Igneous	Pendra, Pakaria, & Deorgaon.	Archaean.

Granite and gneisses are the oldest rock formations in the area and form an undulating country in the eastern side of Amarkantak plateau. The granite gneisses of this area resemble the Bundelkhand gneiss. The main rock is biotite-granite-gneiss. It is usually pink in colour but at times it is white also, largely intruded by pegmatites and quartz veins. The quartz also shows resinous lustre. Its exposures are seen in various nalas from Pendra Road upto Pakaria, e. g., Malhania Nala, Deorgaon (81° 50′ : 22° 44′), Pakaria (22° 42′ : 81° 50′) etc.

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A Plan for Establishing Aluminium Industry in Central India near Rihand Dam, Uttar Pradesh. 1
By
BALRAM K. MAHENDRA.

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The granite gneiss is unconformably overlain by the Lametas composed of gritty and calcareous sandstones. They are white in colour and show spots or patches of red colour and contain veins of secondary silica.

There is no marked unconformity between the Lametas and Deccan Traps. The traps of this area are similar to the Deccan traps of the neighbouring areas.

Laterite usually covers the trap but there are some places where denudation has exposed fresh unaltered trap. Its thickness varies at different places. Exposures are almost continuously seen in various nalas from Pakaria westwards upto almost Amanala Ghat.

Deccan Trap is hard and compact enstatite-augite basalt. There is no marked unconformity between the Deccan Traps and underlying Lametas. There are several flows of Deccan trap, each about 30 ft. thick. The total thickness as seen in the Amarkantak scarp is about 1000 ft. Trap is seen at various places on Amarkantak plateau, such as, Kapildhara Falls (22° 42′ : 81° 42′); Sonebhadra Falls (22° 40′ : 81° 46′); Damgarh (22° 44′ : 81° 46′); Umergohan (22° 46′ : 81° 46′) ; Miria (22° 48′ : 81° 41′). Besides, it also caps some of the hill ranges on the east of Amanala Ghat, namely Rajmergarh. Ash beds along with inter-trappeans are present in Damgarh and near Miria.

Laterite occurs almost throughout the Amarkantak plateau. Where the laterite has been removed by denudation, the underlying basalt is seen exposed. Bauxite is observed at various places in the plateau of laterite. The thickness of bauxite and laterite is variable and may be as much as 35 to 40 ft.

DESCRIPTION OF BAUXITE DEPOSITS

SCARP NORTHWEST OF AMAGHAT TO AMARKANTAK

At the slope between the Amanala and the boundary pillar No. 31 (1894), very good high grade, cream coloured and pisolitic bauxite occurs. The road to Amarkantak lies on the boulders which have come from the top of the plateau. Some of the boulders and masses of laterite met with on the climb up from Amanala are white in colour and are constituted of excellent bauxite. The number of bauxite boulders exceeds in importance to the number of laterite boulders. On the scarp northeast of Amarkantak and the slope to the Amanala below occurs good quality aluminous, pisolitic bauxite of purple colour. Sometimes, pisolites as big as ½″ to ¾″ size are also seen, while major portion of the bauxite has pisolites below ¼″ size and is cream in colour. The deposits on the scarp towards north indicate much improvement in the quality of bauxite. The rock of the scarp from due east of Amarkantak to Amaghat has got good bauxite. The thickness of the boulder bed will have to be determined before anything can accurately be said about the quantity of bauxite. Assuming the minimum thickness of good bauxite to be 2 to 3 feet over an area of 3000 ft. by 1000 ft., the quantity of bauxite will be $\frac{3000 \times 1000 \times 2}{20}$ or 300,000 tons when 20 cu. ft. of the ore weigh nearly one ton. It is possible to get a few hundred tons of good quality bauxite by collecting the boulders on the surface, which can be transported to Pakaria by the cart road or aerial ropeway.

SCARP SURROUNDING BOUNDARY PILLAR NO. 28 (1894)

Bauxite of good quality is seen near the boundary pillar No. 28 (1894). There are two different plateau that are separated by a small scarp of about 15 ft., one above the other. The deposits of bauxite occur on the top of the upper plateau. The outcrops are seen in various neighbouring nalas as well as in the scarp of the plateau. The bauxite occurs in situ. It is grey in colour and of massive variety. The thickness of bauxite bed would be more than 2 to 3 ft. over an area of about 1500 ft. long and 300 ft. wide. The estimated quantity would be nearly $\frac{1500 \times 300 \times 2.5}{20}$ or 56,250 tons, if the minimum thickness is taken to be 2½ ft. The ore can be mined without any difficulty and transported to Jamunadadar which is at a distance of about 3 miles towards southwest and thence to Keonchi by aerial ropeway.

SONMURA HILL (22°39′ : 81°46′)

The river Sonebhadra has its source on the Sonmura Hill, and after flowing in the southeast direction towards the boundary of Rewa territory, it falls into the Bilaspur District. The fall is about 350 ft. and it is possible to see the village of Keonchi while standing near the falls on this hill.

Bauxite of good quality is available near the source of Sonebhadra river. It is grey in colour and sometimes a mixture of grey and cream particles is seen in the bauxite. It has very fine pisolitic appearance. Similar variety is available near the boundary pillar No. 24 (1894) which stands at a distance of few yards from the Sonebhadra Falls towards the north. The extent of the deposit is nearly 1000 ft. long and 200 ft wide and the estimated amount of bauxite is $\frac{1000 \times 200 \times 2}{20}$ or 20,000 tons where the minimum thickness is assumed to be only 2 ft. although it is more. The ore can be transported to Jamunadadar and then to Keonchi by aerial ropeway.

JAMUNADADAR (22°38′ : 81°45′)

The southern most part of Amarkantak plateau is known as Jamunadadar. The area extends from the boundary pillar No 15 (1894), southwest of Amarkantak, in a direction southeast all along the periphery of the plateau towards the boundary pillar No. 21 (1894). Brighuchetra, Chota Purra and Bara Purra are some other places of importance on this hill.

In fact, the bauxite occurs on the whole scarp around Amarkantak plateau though the best quality of ore is observed mostly between the pillar No, 7. (1894) and Jamunadadar. It appears to be a probability that right from the boundary pillar No. 7 upto Sonmura, all along the periphery of the plateau, there is a continuous band of bauxite. This forms a distance of more than 6 miles in length. Mining can be started immediately as the ore can be approached easily.

Several exposures of bauxite are seen in Briguchetra and in the neighbouring nalas and many other places. It occurs in situ. Two plateau are formed at some places where the scarp is divided into two separate scarps, one lying 20 ft. below the other. The upper portion of the overlying scarp invariably contains good bauxite underlain by a great thickness of laterite. The megascopic characteristics of the ore from various places are not similar. The colour varies between white, cream and grey and contains low percentage of iron while alumina is high. The ore is mostly of pisolitic variety. The thickness of bauxite is not less than 3 ft. and may be even more than 6 ft. To estimate the quantity of ore, if it is assumed that the half of the ore is good while the rest is of inferior grade and that thickness of the bed is only 3 ft., the total quantity of available ore comes to $\frac{15000 \times 500 \times 3}{20}$ or 1,125,000 tons. The extent of the deposit appears to be more than assumed here.

The quarrying of the ore can be started after selecting a suitable place and the ore can be collected near the terminus of the aerial ropeway and from there transported to Keonchi.

AMARKANTAK SCARP MARGIN

Commercially attractive ore is located on the boundary of Amarkantak and Bilaspur District. Excellent, grey, pisolitic bauxite occurs on the scarp southwest of the temples of Amarkantak facing Kabirpat from across the Amadob gulch. In an old quarry near the Lamni Pass, at Kurum Chatri, rich irregular patches of bauxite are seen with typical laterite. The scarp shows an excellent development of gray bauxite to the north of Kurum Chatri near the boundary pillar No. 9 (1894). Bauxite is frequently concealed under a pisolitic ferruginous mantle, northwards along the scarp.

SCARP NEAR KAPILA SANGAM & ARUNDI SANGAM EXTENDING TOWARDS KABIR CHABUTRA.

Exposures of bauxite are visible on the top of a plateau between Kapila Sangam and Arundi Sangam nalas. The outcrop appears also on the newly constructed Amarkantak-Kabir Chabutra Road. Very good white and grey bauxite can be observed. It is pisolitic near the surface and massive downwards. The road has been built by cutting through the lateritic area and the laterite as well as bauxite boulders are seen on the surface of the road. At a small distance towards west there is a small road cutting in the hill. Bauxite is here again visible in the cuttings as well as on the surface of the road and on the left bank of the Narbaba river.

There is a small temple given the name of 'Chapkabir' about 15 ft. in front of the boundary pillar No. 1 (1894). The temple is built of the blocks of bauxite and laterite and stands on a foundation of laterite bed rock. The hill all round is called 'Kabir-Chabutra Hill', and a part of it lies in Rewa and the other part in Mandla District. On the hill within the Rewa territory, excellent white bauxite was observed. A detailed study might prove plenty of high grade ore in this area.

AREA SURROUNDING KAPILDHARA

The Narbada river plunges over a 'fall' of about 150 ft. high at a distance of 4 miles from Amarkantak towards the north. Towards the east is the watershed between Narbada and Johilla river. At a distance of one mile north of Kapildhara fall occurs pink massive as well as pisolitic bauxite. The whole area is covered by soil and bauxite is only seen in the scarps and cuttings of nalas. It is not difficult to construct a road to take the quarried ore to Kapildhara. The ore can be transported from Kapildhara to Jamunadadar by the motorable road already in existence.

DAMGARH (22°43′ : 81°43′)

At a distance of about 2 miles towards north from Kapildhara is situated the village of Damgarh on a small hillock which is entirely composed of pink pisolitic bauxite. The variety of the ore has got pisolites as big as ¼" in diameter. The hillock is about 500 ft. long and 500 ft. wide and the thickness of bauxite is about 4 ft. The amount of ore is estimated to be more than $\frac{500 \times 500 \times 4}{20}$ or 50 000 tons.

HILLOCK AROUND THE DAK BUNGALOW

In an old abandoned quarry, a short distance in northwest direction from the Dak Bungalow, white as well as grey bauxite was observed. In the area around the Amarkantak Dak Bungalow there is a good deposit of bauxite. The Dak Bungalow is also built of the blocks of laterite and bauxite, which must have been dug from the quarry located on the hillock nearby. The ore forms a good percentage of the surface rock. The bauxite is seen only in the slopes towards the various nalas as the top of the plateau is covered by ferruginous clay and laterite. It is quite apparent that whole of the hillock contains laterite and bauxite below the surface soil. The bauxite occurs in situ and is usually pisolitic grey and white in colour while pink variety is also seen. The amount of bauxite may be more than $\frac{400 \times 400 \times 2}{20}$ or 16,000 tons, if the minimum thickness of the deposit is considered to be 2 ft. and the extent of deposit only 400 ft. by 400 ft.

NEAR THE CROSSING OF THE AMARKANTAK-BASONIA ROAD & BARATI NALA

Many deposits of bauxite can be seen all along the Amarkantak-Basonia Road beyond the crossing of the road and Barati nala. After the crossing, bauxite is exposed on the left bank of the nala and extends along the nala for about more than two furlongs. Good bauxite is visible at the top of the scrap which changes into more ferruginous variety downwards and the lower beds are of laterite. The bauxite is of pisolitic pink and whitish grey variety but a greater portion consists of pink variety. It is considered as one of the deposits where quarrying can be commenced immediately. The ore can be transported to Kabir Chabutra by road and thence to Pendraby the Amarkantak-Pendra Road. Taking into consideration that good bauxite is available over an area of 1500 ft. long and 600 ft. wide and the minimum thickness of the bed is 2½ ft. the amount of bauxite should be $\frac{1500 \times 600 \times 2.5}{20}$ or 112,500 tons.

BAITARNI NALA AREA.

Some bauxite occurs on the raised ground beyond the Amanala Road towards east of Baitarni Nala. A large portion of high ground is composed of bauxite occurring with laterite. Though a fair quantity of bauxite may be available, yet the area does not seem to be very promising.

PARHAMANADADAR (22°44′ : 81°46′).

The scarp all along the plateau from the boundary pillar No. 35 (1894) passing over Mansakari, Gundarki, Lithwadadar, Parhamanadadar, upto Paraunadadar shows occurrence of laterite But at several places rich pockets of high grade bauxite are also met with such as between boundary pillar Nos. 35 and 36 (1894) and between boundary pillar nos. 37 and 39 (1894). The ore occurs in patches as well as regular beds. Bauxite is of pisolitic variety with a peculiar size of pisolites as big as ¾″ to 1½′ in diameter. A thin mantle of ferruginous clay covers the bed of bauxite varying in thickness from 2 to 6 ft. Assuming 2 ft to be minimum thickness over an area of one square mile, the amount of ore is estimated to be $\frac{5000 \times 5000 \times 2}{20}$ or 2,500,000 tons.

JALESHWAR (22°45′ : 81'46′)

Bauxite of very good variety is observed between boundary pillar No. 41 and 42 (1894) on the Jaleshwar scrap about 3500 ft. high. Pistolitic cream coloured as well as grey bauxite is available in this area. The area is motorable and can be easily connected with Basonia-Amarkantak Road which passes through the scrap. It can be connected with the Amarkantak-Pendra Road at a point near Baitarni nala by constructing a small wooden bridge.

UMARGOHAN (22°47′ : 81°37′)

The village of Umargohan is situated on the track connecting Choktipani and Ponrhi Chhot. The place lies in the valley of Johilla river. and is at a distance of seven miles north of Amarkantak. Bauxite was not observed at Umargohan proper but occurrence of high grade bauxite containing 57.1% Al_2O_3, 1.14% SiO_2, 2.73% Fe_2O_3 and 8.75% TiO_2 at Umargohan has been mentioned by Dr. C. S. Fox and Mr. K. P. Sinor. It may be that the ore is found on flat topped hills lying northeast of the village of Umargohan. This ore is of good grade, but it has no economical importance at present because the place is inaccessible.

CHITA PAHAR (22° 46′ : 81° 44′) and PHARISEMAR (22°44′ : 81°42′).

A road from Kapildhara connects Pharisemar which is at a height of 2750 ft. It is at a distance of 2 miles due north of Damgarh. Towards northeast is Chita Pahar at an average height of 3600 ft. The range is flat topped and consists of Deccan Trap. There are numerous patches of high grade bauxite with low silica content all along this range, from Pharisemar upto Miria. The area is covered with thick and dense vegetation and could not be observed due to its inaccessibility. These bauxite deposits are the feeders of bauxite boulders found in several nalas flowing westwards from the Chita Pahar and joining Narbada ultimately.

MIRIA (22° 57′ : 81° 41′)

The village of Miria is about 3 miles northwest of Pharisemar. There is a spur of hill about 200 ft. above the ground level just northeast of Miria. On the slope of it are found plenty of bauxite boulders lying in situ. The ore is pisolitic grey and appears to be of very high grade. A band of bauxite, about a quarter mile long, also extends a little south of east and north of west in the village of Miria. Here the ore is of pink colour and massive variety. It has somewhat silky lustre and is soapy to feel. The bauxite is of excellent quality and regarded as a first class ore.

The deposit contains a fairly large amount of bauxite over an area of 1000 ft. long and 400 ft. wide while the thickness is more than 4 ft. The total quantity will be $\frac{1000 \times 400 \times 4}{20}$ or 80,000 tons. The deposit can be exploited only after constructing a road to connect Chita Pahar, Pharisemar, Damgarh and Kapildhara.

HARAI (22° 48′ : 81° 39′)

The village of Harai is situated at a distance of 2½ miles northeast of Miria. First class, highly aluminous bauxite occurs near Harai. The means of communication are very poor and the area lies in the interior of forest and a successful undertaking is not possible under the existing conditions. There is a foot-path which leads to Pendra Road via Miria, Parkighat and Harratch. Pendra Road is at a distance of 19 miles from Harai by this foot-path.

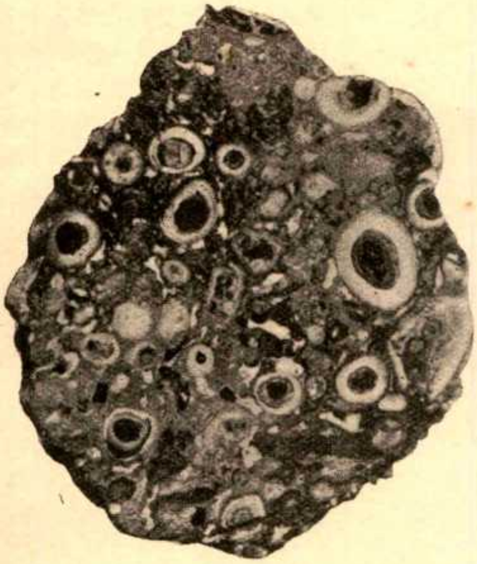


Fig. 3

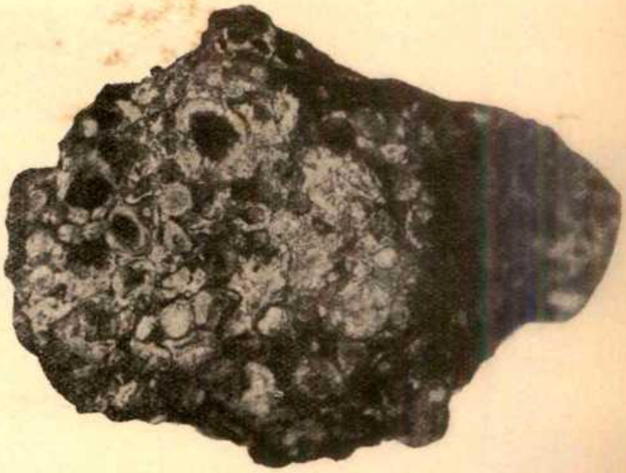
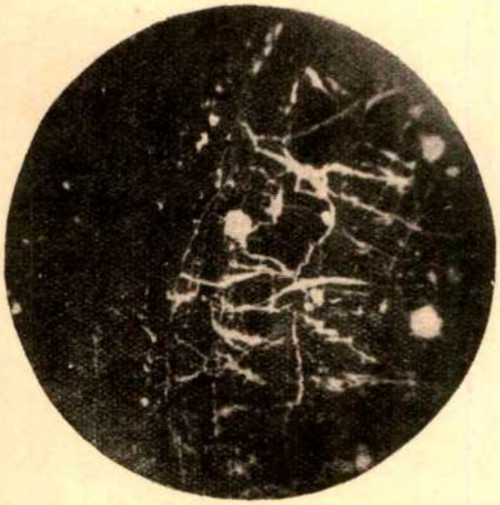


Fig. 4



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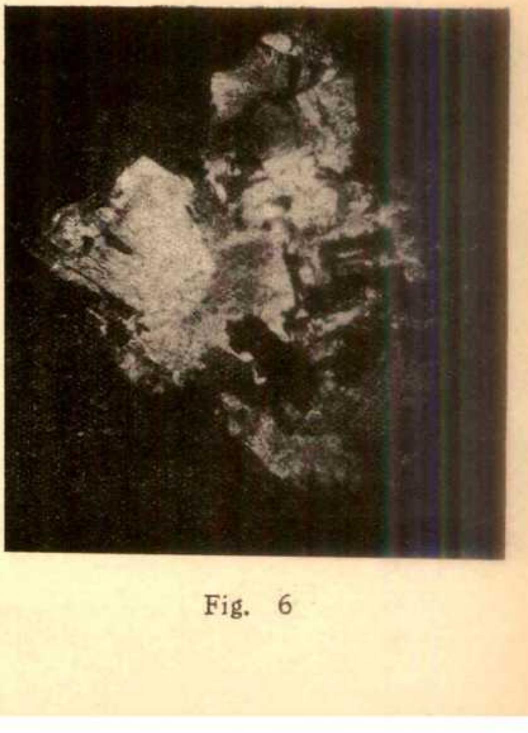

Fig. 6

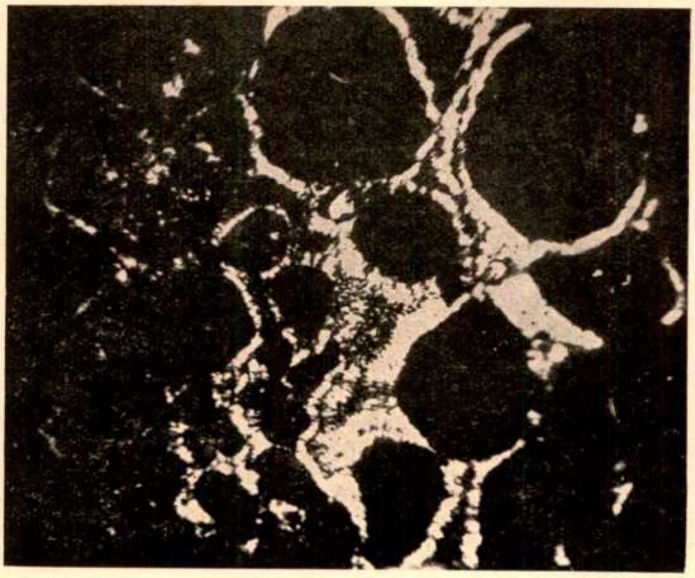

Fig. 7

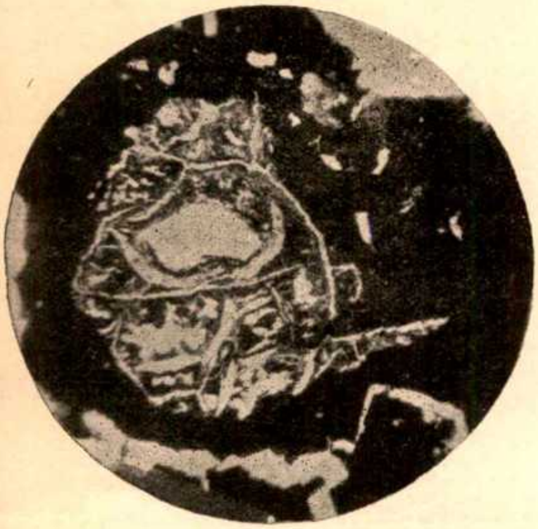

Fig. 8

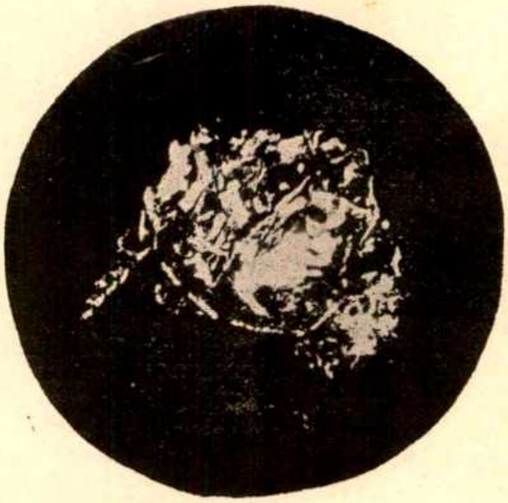

Fig. 9

MOHNDIH (22° 48′ : 81° 38′)

At a distance of 1½ mile northwest of Harai lies the village of Mohndih. Here again highly aluminous bauxite similar to that found at Harai and Miria is available. The deposit can, however, be exploited only after the transport difficulties are solved.

CHARACTERISTICS OF AMARKANTAK BAUXITE.

The importance of the study of physical and chemical nature of bauxite can not be over-emphasised. The quality of the ore must be examined both physically and chemically to determine its suitability for treatment in the Bayer process. An aluminous ore having the same composition (chemical) may differ in the process to be applied for the manufacture of alumina from it. Presence of Gibbsite in large amount, in bauxite, is one of the very important features which decides the chemical treatment to be followed for the extraction of alumina.

Bauxite is theoretically composed of $Al_2O_3.2H_2O$ and hardly conforms to any exact chemical composition. Usually the ore has a chemical composition mid-way between Diaspore $Al_2O_3.H_2O$; and Gibbsite $Al_2O_3.3H_2O$; sometimes it is near to one and some times near the other. It is an earthy mineral and occurs in a variety of forms, but usually has the pisolitic or oolitic structure, with rounded concretionary grains embedded in a clay-like mass.

MEGASCOPIC CHARACTER.

Megascopically, deposits of Amarkantak area may be classified as cream, bluish grey, pink coloured pisolitic and massive bauxites. Both pisolitic and massive varieties of bauxite have been found to be equally distributed on the Amarkantak Plateau. The usual size of pisolites ranges between ¼ to ½ of an inch in diameter. The periphery and more often the kernel of the pisolites has been observed to be ferruginous and red in colour.

A characteristic variety of bauxite was found to occur near the boundary pillar No. 35 (1894) and shows particularly very big size of the pisolites. The size of the pisolites varies from ¾ to 1½ inch in diameter. The structure indicated on fracture reveals a concentric arrangement of alternate layers of dark brown and greyish yellow alumina and ferric hydroxide.

Amarkantak bauxite usually has a hardness value of 3.5 to 4.5 (Moh's scale) and its specific gravity usually ranges from 2.4 to 2.7.

Study of some typical specimens of bauxite from Amarkantak plateau is detailed below :

SAMPLE No. 34/107.

Bauxite of this type was observed at a height of 3000 ft. above sea level on the slope between Amanala Ghat and the top of Amarkantak. It was not found to occur in situ and most probably it might have come from the top of the plateau. It has a cream coloured appearance and shows a slight tinge of pink colour at some of the specks. Average pisolites are of a very small size and are not observed distinctly. Their size is about $\frac{1}{8}$th of an inch in diameter. The concentric structure is not observed conspicuously. The matrix in which the pisolites are embedded consists of fine grained white material. It is hard and compact bauxite. Hardness is about 3.5 to 4. Only a few cavities are observed, which are lined by yellowish white mineral. It breaks with an uneven fracture. The matrix surrounding the pisolites is found to be harder than the pisolites.

SAMPLE Nos. 19/105, 20/105, 22/105, 21/105

These samples of bauxite were collected from a pit, on the side hillock on which the Dak Bungalow of Amarkantak is situated and also from the nala behind the Dak Bungalow. The bauxite is of hard and compact variety. The specimens show a very fine structure, almost massive and are greyish white and pink in colour. The whitish colour is predominant. The fracture shows uneven and sharp edges. Average specific gravity is 2 35 and hardness varies between 3.5 to 4.

SAMPLE No. 3/101.

The characteristic size of pisolites and the perfectly concentric arrangement of the layers observed in this sample is of interest. The sample was found near Paraunadadar. The bauxite is of ferruginous variety. The pisolites, which are very conspicuous are as big as 1" in diameter. The fresh broken and finely polished surface of bauxite reveals the peculiar structure of pisolites. The kernel and the periphery of the pisolites are usually ferruginous with a white aluminous body. The kernel is surrounded by concentric arrangement of alternately dark brown ferruginous and white aluminous material. The pisolites vary in size. The cementing material or the matrix into which the pisolites are embedded is of amorphous ferruginous mineral, yellowish red in colour. It shows an uneven fracture and breaks up with sharp edges. It is hard and compact and indicates a fine-grained amorphous texture. The hardness value is about 4 and specific gravity 2.7.

SAMPLE No. 12/103

The sample was taken from a big boulder on the Jamunadadar Hill. All around the hill the bauxite boulders can be observed. It shows pisolites of yellowish dirty brown colour embedded in a fine matrix which is predominantly white in colour and slightly tinged with yellow and pink specks at some places. The matrix is predominantly of aluminous mineral.

SAMPLE No. 2/101

This sample was collected from the hill through which the footpath leading to the Amarkantak plateau passes over the slope. The place is at a distance of about 11 to 12 miles from Gaurala. Pisolites are very common and are almost uniform in size. It shows an intermixture of white and pink pisolites. Though predominantly aluminous, it appears to contain some iron which may not be very high.

SAMPLE No, 105/795

The sample was collected from the area between boundary pillar Nos. 31 and 32. Bauxite is of hard and compact nature. The pisolites are observed to be very well developed. The kernel of the pisolites is of light brown colour while the surrounding concentric circles are thick and cream in colour. The matrix is also of creamy colour with a slight tinge of grey. The specific gravity was found to be 2.5 and hardness 3.75.

SAMPLE No. 28/105

The sample was found at a distance of about 100 yards towards north from the crossing of the Amarkantak-Basonia and Barantinala. Bauxite is of massive nature and is almost uniformly coloured light grey. Some small specks of pinkish white material are also observed. It is very hard and compact. On fracture it breaks up with sharp edges and uneven surface appears,

MICROSCOPIC CHARACTER

The microscopic examination of Amarkantak bauxite was carried out particularly with the object of studying the presence of gibbsite which is of primary importance. Only those bauxite containing high percentage of gibbsite can be easily digested and treated successfully by the Bayer process. The microscopic study revealed the presence of crystalline gibbsite in all the specimens of Amarkantak bauxite. The mineral was more common in the pisolitic varieties of both aluminous and ferruginous specimens. It was seen to be consistently present in the matrices of the pisolitic bauxites. Many of the pisolites were observed to be veined with crystalline gibbsite in nests and patches. The interstices breaking up continuity of the pisolites were always found to contain crystalline gibbsite. In some of the specimens, the crystalline gibbsite forms the centre of the pisolites which is surrounded by the alternate layers of slightly ferruginous and mostly aluminous mineral. Most of the specimens show absence of diaspore. Hardly two or three specimens indicate the presence of diaspore and even in those only a few specks of it are observed. Diaspore exists as very minute and fine crystals. All the observed crystals of diaspore are always found to be surrounded by the crystalline gibbsite. The gibbsite occurs in substantially large amount and may vary from 70 to 80% or more.

The micro-structures of some of the typical sections examined under the microscope are described below.

SPECIMEN No. 19/105

Under the microscope, in thin section, this bauxite shows yellowish brown pisolites embedded on an amorphous matrix which may be cliachite. The pisolites are traversed by irregular cracks and interstices which are filled with a net-work of crystalline gibbsite. The amorphous material appears white under the reflected light. Under crossed nicols, the interstices show a very fine crystalline arrangement of upper high order colour. Cracks and oolitic structure are clearly revealed. The extinction was found to be at 18°. There is no doubt that this bauxite contains nearly 70% to 80% of gibbsite. Similar micro-structure is seen in almost all the other micro-sections of Amarkantak bauxite.

SPECIMEN No. 17/104

The micro-structure revealed by this specimen indicates a ground mass of almost wholly composed of crystalline gibbsite. A nest of inter-grown crystals of gibbsite showing twin effects is very predominant. The study between crossed nicols, natural light revealed the presence of crystalline gibbsite which occurs in an amorphous matrix of aluminous mineral (Cliachite). All the crsytals together produce a recticular structure.

SPECIMEN No, 15/104

The amorphous character of the oolitic pisolite and the crystalline matrix are well developed in this specimen. Inside the veins of pisolites is seen slight development of gibbsite. The crystalline structure is perfectly apparent between crossed nicols. The crystalline coating of pisolites is seen in the matrix and in some pisolites. One or two specks of diaspore are also visible.

SPECIMEN No. 5/102

The thin section of this specimen, collected from near the source of Son Bhadra river shows the nucleus or centre of pisolites consisting of gibbsite. The concentric layers surrounding the gibbsite may be cliachite. Gibbsite forms the major portion of the material.

SPECIMEN No. 23/106

This bauxite shows pisolitic structure, pink in colour. The pisolites are entirely composed of amorphous and translucent material. The crystalline coating of gibbsite to the pisolites and development of crystalline structure in the matrix of pisolitic bauxite, are also well observed.

CHEMICAL COMPOSITION

Not only physical characteristics but also the chemical behaviour of the bauxite determine its suitability for treatment for recovery of alumina. Numerous samples were analysed and results obtained from the important ones are given in Table I. The low silica content is of much importance from the economic point of view because a higher silica means greater loss of caustic soda and alumina in the Bayer process. However, to arrive at a definite conclusion on the suitability of bauxite for the manufacture of alumina, it is necessary to run an elaborate series of digestion and precipitation tests on representative samples.

TABLE I

BAUXITE FROM AMARKANTAK, COMPOSITION PERCENT*

Sample No.	Moisture	Loss on Ignition	SiO_2	Fe_2O_3	TiO_2	Al_2O_3
31/107	1.13	24.90	2.15	5.60	5.46	61.74
2/103	1.24	24.94	1.27	7.01	6.25	60.4
15/104	0.72	27.26	1.72	7.6	5.63	57.8
20/105	0.52	27.2	1.1	2.67	7.04	62.02
34/107	0.76	26.88	0.46	1.90	4.01	65.02
19/105	0.99	27.92	1.90	8.91	6.02	51.90
23/106	1.02	26.80	1.75	8.09	7.19	52.02
18/104	1.60	22.67	1.21	0.30	7.20	65.62
22/105	1.51	24.32	2.58	4.76	6.92	60.97
17/104	1.42	22.7	1.02	4.75	7.98	64.87
6/102	0.75	26.72	0.89	4.53	6.75	66.02
2/101	1.2	25.7	1 1	6.22	8.45	58.23
20/105	2.1	25.82	1.55	6.20	8.09	57.5
35/107	1.32	24.37	1.09	5.32	6.18	63.2
7/102	1.21	26.94	0.40	2.10	4.25	66.02

MINING AND EXPLOITATION

The observations have indicated that the quantity of good bauxite reserves on the Amarkantak plateau can be estimated to be about 4,000,000 to 5,000,000 tons conservatively. The estimate is, however, based upon the exposures studied near the margins of the plateau and the actual deposit is likely to be considerably big.

The exploitation of the plateau can be undertaken very advantageously, since the total area covered does not exceed fifteen square miles and most of the deposits are fairly large in size to be worked individually to supply the needs of the aluminium plant.

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*The samples were analysed by the author at the laboratories of the College of Mining & Metallurgy, Banaras Hindu University, Banaras

In addition, potential reserves of bauxite are also available in the adjoining districts of Central Provinces such as Katni, Jubbalpore, Saugor, Senoi, Mandla, Bilaspur, Chattisgarh and Balaghat.

QUARRYING

The outcrops can frequently be quarried by means of open pits, but when the bauxite bed dips away to appreciable depth the mineral has to be mined in the same manner as coal or other bedded deposits by working in inclines and levels. The ore occurring in irregular pockets can be worked by open pit operations. When the ore body or bed lies in undulating country it is often possible to get over water difficulties by cutting drainage channels, otherwise pumping must be resorted to in the usual way. A proper selection of site is essential before starting quarrying operation at the plateau. The operation will consist of removing or stripping the over-burden under which lies the bauxite deposit. The over-burden at places, may consist of a thin layer of soil or unconsolidated beds of clay. The maximum depth that can be economically stripped depends upon a number of factors, among which are the thickness of the bauxite bed, the character of the over-burden, and the cost of disposing it. It may be mentioned that at some places as much as 40 to 50 ft. of overburden have been removed but this would not be the case with the Amarkantak deposits. It is important to keep the bauxite as free as possible from the mixing of clay or overburden which contains undesirable impurities.

The overburden on the Amarkantak deposits is not very thick and generally simple removal of it by hand and cleaning the surface of the ore in the same operation will be required. Where the overburden is of moderate thickness, it may be more economical to remove the bulk of it by means of steam shovels or other stripping apparatus, after which stripping by scrapers and by hand and cleaning of the ore surface are necessary before commencing mining operation. Stripping by hand can be generally followed.

The bauxite will be worked in vertical face by open pit methods. Where the thickness of the bauxite bed or pocket is moderate, the ore should be mined in one bench. In a few places, however, where the bauxite masses are of considerable thickness, two benches and occasionally three benches may be used. Bauxite is generally moderately hard and compact, therefore explosives are used for blasting. After the ore is broken down, it may be loaded by hand or steam shovel, into the trolleys and hauled to the loading station of the aerial ropeway. The ore may be mined at places, by pick and shovel, and carted away in wheel barrows, requiring no power equipment etc.

COST OF QUARRYING :

One labourer can easily mine more than half a ton of bauxite per day, and 500 labourers will be required to mine about 250 tons of ore per day. It should be possible to secure labour at the rate of Rs. 2/8/- per day, each man, in the Amarkantak area.

The cost of mining bauxite has been estimated as given below taking into consideration about 300 working days in a year.*

500 labourers @ Rs. 2/8/- per day.	Rs.	3,75,000
20 Supervisors, headmen, foremen etc. @ Rs. 200 per month.		48,000
One Mining Engineer @ Rs. 1000 per month.		12,000
Miscellaneous and overhead expenses including mining tools etc.		1,65,000
Total...Rs.		6,00,000

The cost of mining 75,000 tons of bauxite per year will therefore come to not more than Rs. 6,00,000. This means the mining charges will be approximately Rs. 8/- per ton.

TRANSPORT OF ORE

Before any successful exploitation can be undertaken, it would be necessary to establish the means of transporting bauxite from Amarkantak to Pendra Road, the nearest railway station. The distance between Amarkantak and Pendra Road, as the crow flies, is nine miles. Pendra Road is the railway station on the Katni-Bilaspur section of the Eastern Railway. From Pendra Road there are two routes leading to Amarkantak. One is via Pakaria about 14 miles long, while the other is via Keonchi and is 22 miles long. The former is the foot path usually taken up by pedestrians, though carts can ply on this road upto Pakaria, which is at a distance of 8 miles from Pendra Road. The route via Keonchi is through a good road and remains motorable throughout the whole year except the rainy season when the rivers and nalas become flooded and the temporarily constructed bridges collapse.

On the road via Pakaria, the country is flat upto a place known as Harriotts Point, about 10 miles from Pendra Road. The steep ascend commences from this place and continues for nearly three miles till Amarkantak plateau. The topographical features of these three miles are such that the construction of railway would be too expensive. However, the construction of an aerial ropeway would possibly prove economical.

The road via Keonchi is on flat country upto Keonchi. The height of Pendra road is 2000 ft. above sea level while that of Keonchi is 1900 ft. Keonchi is at a distance of 14 miles from Pendra Road and 13 miles from Amarkantak via Kabirchabutra. The road ascends very steeply from Keonchi to Amarkantak. There is a climb of about 1500 ft. in a distance of 13 miles and evidently there is an average gradient of 100 ft. per mile. The trucks can easily ply over this road from Pendra Road to Amarkantak, covering a distance of about 27 miles.

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*The cost figures given hereafter were collected in the year 1949 and may be found to be fairly representative today with some amount of fluctuations.

Jamunadadar is a flat country and the amount of vegetation is very small. The trucks can go over throughout the whole periphery of Jamunadadar and right upto the place of mining, if a place is constructed. The road can be joined to Amarkantak-Kabirchabutra Road some where near Kapila Sangam. The cost of constructing this road will be about Rs. 2000/- per mile and a three mile long 'kuccha' road would cost about Rs. 6000/-. The working face of the quarry may be assumed to be at an average distance of 28 miles from Pendra Road via this road. Out of these 28 miles, the loaded trucks will have to descend a distance of 14 miles from the quarry upto Keonchi and the rest 14 miles will have to be covered over a flat country. Evidently, there may be little consumption of fuel during the first 14 miles of descent. On return journey, the empty trucks will cover a distance of first 14 miles on a flat country and will have to ascend 1500 ft. during the rest 14 miles.

Should the immediate exploitation be aimed at, the vehicle transport could be employed conveniently and the crude oil trucks would prove to be quite economical. A crude oil truck can carry about eight tons of bauxite at a time and make two trips per day. The amount of bauxite transported thereby would be 16 tons per day. The trucks would consume about 1 gallon of crude oil per run of 8 miles. The cost of transport may be worked out as under :

Crude oil 14 gallons for 112 miles @ Rs. 1/4/- per gallon.	Rs. 17-8-0
Mobil oil about 1 gallon @ Rs. 3½ per gallon.	3-8-0
Labour (one driver Rs. 4/- and one cleaner Rs. 3/-).	7-0-0
Tyres and tubes (ten in number).	20-0-0
Depreciation.	40-0-0
Miscellaneous expenses.	8-0-0
Total expense for transporting 16 tons.	Rs. 96-0-0

Sixteen tons of bauxite would be transported for Rs. 96/- i.e. at the rate of about Rs. 6/- per ton. An amount of Re. 1/- must be added to it for the loading and unloading charges of one ton of bauxite. Rupees 7/- per ton may be therefore accounted as transporting charges.

The cost of bauxite available at Pendra Road railway station may be estimated to be as follows :

Cost of transport, per ton	Rs. 7-0-0
Mining expenses, per ton	Rs. 8-0-0
Royalty, per ton	Rs. 1-0-0
Overhead expenses	Rs. 5-0-0
Total	Rs. 21-0-0

AERIAL ROPEWAY.

Aerial ropeway is, however, considered to be the best and most efficient means of transport over hilly places. The topographical features of the country between Amarkantak and Pendra Road is suited for installation of an aerial ropeway system.

Three sites are suggested for installation of the aerial ropeway system.

(a) An aerial ropeway can be installed between the plateau on the eastern side of Amarkantak and the Amanala Ghat (Fig. 1). The loading station can be at some point near the boundary pillar No. 31 (1894) or at the crossing of the footpath and the boundary of Rewa territory (3501 ft. above sea level) and the unloading station at the Harriotts' Point or Amanala Ghat (about 2500 ft. above sea level). The length of the ropeway would be about one mile, as the crow flies. The ore can be quarried along the periphery of the plateau and collected at the loading station and transported to Amanala Ghat by aerial ropeway whence it may be sent to Pendra Road via Pakaria by the old road already existing. This road may be turned into a 'pukka' road at a small expense. Ballast, a very good road material is available throughout the whole length.

It is very difficult to construct a road from Harriotts' Point to the top of the plateau because there is a steep ascend and the footpath lies over boulders and is about 3 miles long by a circuitous path. Construction of the road would be unprofitable while the aerial ropeway would prove to be economical.

(b) A direct ropeway can be erected between Amarkantak and Pendra Road, The distance between Amarkantak (3460 ft. above sea level) and Pendra Road (2029 ft. above sea level), as the crow flies, is 11 miles. The length of the ropeway being considerable, though much within the limits of an economical installation, the initial capital expenditure would be high. It may not be considered feasible unless the work is to be started on a big scale.

(c) An aerial ropeway can be installed between the eastern side of the plateau of Amarkantak and Pakaria. The country between Amarkantak and Pakaria is very undulating with sudden escarpments. Pakaria is a plain country and from the village a 'kachha' road leads to Pendra Road. This cart road can be converted into a 'pukka' road as suggested under proposal (a) above. The length of the ropeway will be about 5 miles.

(d) An aerial ropeway may be installed between Jamunadadar and Keonchi. The loading station can be at a suitable point of Jamunadadar (3250 ft. above sea level) and the unloading station at Keonchi (1913 ft. above sea level). The length of the ropeway would be between 2 to 3 miles.

The last proposal (d) is considered to be the most favourable one.

TROLLY LINE.

It would be desirable to collect the ore from all over the Amarkantak plateau at the loading station of the aerial ropeway. A trolly line running around the periphery of the plateau is considered most economical for this purpose. The length of the trolly line would be about two miles. The initial capital expenditure on this project may be about Rs. 50,000/-. It can be estimated that Re. 1/- will be sufficient to account for the expenditure on the transport of one ton of bauxite by trolly line service upto the loading station of the aerial ropeway.

The ropeway to be installed should be capable of carrying about 25 tons of ore per working hour. It may be operated for ten hours per day thereby handling about 250 tons of bauxite per day, i.e., about 75,000 tons per year. At a slightly higher operating cost and by working for longer time every day, greater amount of bauxite may be handled to meet the increasing demand, if any. This quantity would be more than sufficient for a plant manufacturing 10,000 to 15,000 tons of aluminium per year.

The cost of installation of the ropeway system may be about Rs. 1,00,000. The total capital outlay, including the trolly line system, would be about one and a half lac of rupees.

The ore can be transported from the plateau to Keonchi by the proposed aerial ropeway. From the unloading station at Keonchi it may be carried to Pendra Road by crude oil trucks. A light railway line may be also installed between Keonchi and Pendra Road. Pendra Road is at a height of about 2000 ft. and Keonchi about 1900 ft. above sea level. The country between the two is flat and has no undulations. A railway project can be worked out without difficulty. The investment may be about Rs. 700,000 including the cost of putting the rails and about Rs. 300,000 may be required for the engines, carriages and wagons, etc.

CAPITAL INVESTMENT :

Railway lines 14 miles long	Rs. 700,000
Engines and Carriages etc.	Rs. 300,000

The railway may be presumed to cover an average distance of 10 miles per hour and make four trips per day. 100 tons of ore could be easily carried in one trip and 400 tons could be transported to Pendra Road every day. The running expenses of the railway project may be worked out as under :

2 tons of coal per day (400 lbs. per hour)	Rs. 40 0 0
Labour & staff per day pay	Rs. 40 0 0
Loading and unloading charges	Rs. 120 0 0
Interest and depreciation	Rs. 300 0 0
Contingencies	Rs. 25 0 0
Total	Rs. 525 0 0

About 400 tons of bauxite would be transported at a cost of about Rs. 525, i.e., about Rs. 1/4/- per ton.

This would be only if an industrial concern undertakes to workits own siding and transport about 125,000 tons of material per annum. The cost of transporting material, however, may go upto Rs. 3/- per ton, if only 75,000 tons of bauxite has to be transported and there is no other traffic as a means of earning, though extra income may come from transporting timber from the forests of Amarkantak and surroundings. The bauxite would be then available at Rs. 19/- per ton at Pendra Road as accounted below :

TABLE II

ESTIMATED RAW MATERIALS REQUIRED BY ALUMINIUM INDUSTRY.

Production 10,000 tons of Aluminium per Annum.

ALUMINA STAGE

Bauxite (Grade A)	40,000 to 50,000 tons
Quicklime	1,200 to 1,800 tons
Soda Ash*	14,00 to 2,000 tons
Coal, oil, gas, or electricity to produce from†	160,000 to 200,000 million B.T.U.

ALUMINIUM REDUCTION STAGE.

Alumina (from above)	20,000 tons
Carbon paste :	5,800 to 6,500 tons.
Petroleum coke	4,060 to 4,620 tons.
Pitch	1,750 to 2,140 tons.
Aluminium fluoride‡	760 to 840 tons.
Cryolite (natural)	480 to 530 tons.
Synthetic	290 to 320 tons.
Electric Energy	200 to 224 million K.W.H.

Cost of Mining, per ton.	Rs. 8 0 0
Transport cost by trolly line, per ton	Rs. 1 0 0
Transport cost by aerial ropeway, per ton	Rs. 1 0 0
Transport cost by the light railway, per ton	Rs. 3 0 0
Royalty, per ton	Rs. 1 0 0
Depreciation and interest	Rs. 4 0 0
Miscellaneous and overhead expenses	Rs. 1 0 0
Cost of bauxite at Pendra Road station, per ton.	Rs. 19 0 0

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*Caustic Soda may be used instead, quantity required being 3,200 to 4,000 tons.

†Since the cheapest fuel available to an alumina plant in quantities is used, only the heat values can be given. If coal were used exclusively, the requirements to produce 20 000 short tons of alumina would approximate 50,000 tons of coal depending upon the calorific value of coal.

‡Aluminium fluoride may be used either in the natural form of cryolite obtainable only from Greenland, or in the synthetic form. Actually most plants use both.

It has been already estimated that if the crude oil trucks are employed to transport, bauxite will be available at Pendra Road at Rs. 21/-per ton. On the other hand if an aerial ropeway and railway project is installed, bauxite will cost Rs. 19/- per ton at Pendra Road. A saving of Rs. 2/- per ton worked out on about 75,000 tons of bauxite exploited every year, will result in a saving of about Rs. 150,000 per annum which is favourable.

The exploitation of bauxite, production of alumina and its reduction to aluminium should be undertaken by a single industrial concern which would develop the resources most economically and obtain bauxite at a cost of Rs. 19 per ton.

MISCELLANEOUS RAW MATERIALS.

Aluminium industry in its various stages requires substantial tonnage of several other raw materials, besides bauxite. Of the total nearly half is bauxite, a third is coal or other fuel to fire the kilns in alumina production, nearly eight percent anodes made of petroleum coke and pitch, and the remainder quick lime, soda ash (or caustic soda), cryolite and other supplies. Estimated requirement of raw materials is detailed in the Table II.

The availability of raw materials at a short distance from the production plant is of particular interest to the aluminium industry, since movement of abundant raw materials over long distances means increase in transportation costs.

COAL

The Amarkantak bauxite is advantageously placed because of its proximity to South Rewa Coal fields. Extensive supplies of coal could be available from the Johilla Coal Fields ; Umaria Coal Fields ; Sohagpur Coal Fields ; and Singrauli Coal Fields. The former being operated near the Birsinghpur railway station which is at a short distance of 49 miles from Anuppur—the proposed plant site. After the coal fields of Bengal and Bihar, these Central India coal fields appear to be important in India. Analysis of coal from the Johilla Coal Fields is given in Table III.

TABLE III

Coal from Johilla Coal Fields

Composition Percent.

Total moisture on coal as received	....	...	7.6%
Analysis on air dried coal			**Percent.**
Moisture	...	...	5.43
Volatile Hydrocarbons	...	...	26.80
Fixed carbon	...	....	53.79
Ash	...	...	13.98
			100.00

Net Calorific value of coal as received (Cal.)	5647
,, B. Th. Us ,, ,,	10168

CAUSTIC SODA

The Bayer process of recovering alumina utilises caustic soda for the digestion of bauxite in the autoclaves. The production of one ton of aluminium requires about 0.16 to 0.2 ton of caustia soda. It is sometimes made by the aqueous reaction of soda ash and lime, depending upon the availability and price of the directly bought caustic. Extensive supplies of high grade lime could be obtained from concerns already burning limestone at Satna, Katni, Maihar and Jukehi (Central India) at a very short distance, while soda ash will have to be bought from the manufacturers near Bombay. It is, however, proposed that electrolytic caustic soda should be produced in an adjoining plant as integral part of the alumina works instead of buying it from elsewhere. Caustic soda plant near the alumina house would be able to supply the latter its requirements of caustic in liquid form. The extra cost of evaporating the liquid stuff to the solid caustic soda will be a saving, which is necessary before transportation when made in a distant plant. This would also mean a saving from the extra cost of redissolving the solid caustic to liquid in which form it is used in the Bayer process. This total saving in the extra cost of evaporating and redissolving as well as the extra cost of transportation from a distant plant should affect fair economy in the cost of production of alumina. The amount of caustic produced in excess of the needs of alumina house, could be easily sold because of the vast demand of it in Indian industries. Caustic soda could be manufactured by electrolytic method from sea salt or the Sambhar Lake salt. One of the most important factors in the manufacture of caustic soda being the supply of cheap power, the erection of caustic soda plant near the integrated alumina reduction plant would prove to be very economical.

CRYOLITE

Natural cryolite is something of rarity in that there is only one economical deposit in Greenland. Synthetic cryolite, manufactured from fluorspar is as effective as the natural product and it is now being used preferably because of the high price of the natural product and the necessity of becoming self sufficient particularly during war. Indian fluorspar occurring in Jubbulpore and on the border of Nandgaon and Khairgarh states (central India) contains high silica from which cryolite may be produced by the Humann and Teisler method of digesting sodium fluosilicate with sodium aluminate. The best workable deposit of fluorspar being also in Central India, a plant set up near the proposed aluminium plant will have the advantages of obtaining sodium aluminate produced in the Bayer process ; availability of power and fuel near the site , utilising fluorine recovered from the gases given off from the aluminium reduction cells ; reduction in the cost of production because of the integrated unit ; and favourable central location as regards supply to other aluminium reduction works. Cryolite is also employed in the making of opaque glass, enamel ware, porcelain and, in finely ground form for insecticides and it may not be difficult to find a market for synthetic cryolite produced. The erection of cryolite plant may, however, be deferred for some time, and the industry started with imported natural or synthetic product, depending upon the availability of finance and other factors.

ELECTRODE PASTE

Out of petroleum coke and pitch, the former will have to be obtained from the only source, Assam Oil Company at Digboi and latter is available as a by-product in the process of tar distillation. The present supplies of petroleum coke from Digboi are uncalcined and extra freight is payable on about 25 to 30% weight it loses on calcining. The Digboi works should be willing to install a calcining plant to meet a continuous demand. Since the purity of electrode paste is an important factor, it is a practice to manufacture the paste for feeding the continuous Soderberg Electrodes of reduction cells, at an integrated plant, under direct control and supervision.

ELECTRIC ENERGY

To produce aluminium the electrical energy is required at an extremely cheap rate and in abundance. This consideration, except under exceptional conditions, determines the site of an aluminium plant. In fact, the electricity which is used to make one ton of aluminium would give light to an average house for 15 years.

In the extraction of alumina from bauxite and the various operations necessary to transform pig aluminium into semi-finished products, there is nothing peculiar in the use of electricity. It is used as in other manufacturing processes as power to drive mechanical equipment and as a source of heat. It is however the very essence of reduction of alumina to aluminium where 2. 4 to 2.6 kilowatt year of electric power are required to produce one ton of aluminium.

An important feature is the continuous use of electric energy. Consequently, the electrolytic plant producing aluminium is able to operate at a very high load factor of 98% or even more. This fact is extremely important, both for the aluminium industry, which finds thereby a condition favourable to low cost of electric energy, and for the power industry.

Thermal power stations for reduction plants cannot be considered feasible in India. Let us assume that coal can be available at a minimum price of one pie per lb. which means that the cost of one ton of coal will come to Rs. 11/10/8. It has been reported that in most efficient thermal power house of the capacity of more than 30,000 K.W., the consumption of first grade coal is from 1.5 to 1.75 pounds per K.W. The Indian coal being somewhat inferior it may not be considered possible that less than 2 to 2.5 lbs. of it will be required to generate 1 K.W. hour of energy. Estimating at the rate of 1 lb. of coal at a price of 1 pie, the cost of fuel expenses to generate one K.W. hour of energy will alone come to nearly 2. 5 pies to which must be added the cost of installation of plant, operational charges, overhead expenses, etc. Even at the rate of 2.5 pies per K.W. hour, the cost of power comes to Rs. 260 per ton of aluminium, while the actual cost of generation will be higher, and uneconomical for the aluminium industry.

RIHAND POWER PROJECT

Electric energy from hydro-electric power development projects would be made available to the aluminium industry at a reasonable cost. Out of the numerous schemes in India, Hirakund, Rihand and Damodar projects would be of interest to aluminium industry. The Pipri Dam and Power Station Project on the Rihand Dam is the most important scheme contemplated by the Government in the Central India. It could be the source of power supply to the proposed aluminium plant. Pipri is ideal for a dam site. Massive granite rocks, free from fissures and faults, expose themselves to full view here in the river bed on the flanks. The granite rock is sufficiently wide to fully accommodate a dam 300 ft. high.

The scheme is capable of meeting a firm demand of 132, 400 K.W. at 100% load factor. No steam or other support is required for this power. A further block of 24,200 K.W. at 100% load factor can, however, be generated with proper steam or hydro-electric support. Steam support will be more expensive than hydro-electric which is economically available at Obra site, some 20 miles down stream, where a pick up dam for 70 ft. net head can be constructed. The subsidiary Obra Dam will make the power available from the combined Pipri and Obra project to 170,200 K.W. (continuous at 100% load factor). Moreover, the unit cost of power generated at Obra Dam, which derives its water potential from the Pipri reservoir is expected to be even lower than the unit cost from Pipri project.

The power plant at Rihand will have an installation of about 240,000 K.W, comprising of a number of suitably sized units ranging from 20,000 K. W. to 50,000 K.W. each.

It is expected that half of the power will be utilized in metallurgical and other electro-chemical industries. The load factor for this power will be in the neighbourhood of 95%. The load factor for the balance of power transmitted may be 60%.

The total cost of the project including all overhead indirect charges has been worked out to 21. 12 crores of rupees.

It has been estimated by the Government of Uttar Pradesh that the cost of power generated from Rihand hydro-electric project shall be about 2.4 pies or one fifth of an anna. The power from this project shall be therefore appreciably cheaper than that from any other hydro-electric scheme in India. It should be noted that in working out the cost of generation of the Rihand scheme no credit has been taken for any related benefits of a multi-purpose scheme, whereas it is not known if such is also the case with the schemes of Norway, Sweden and Canada. The Rihand power project is already under progress. Preliminary work was started in 1945. Most of the machinery for the new Cement Factory constructed by the Industries Department of the Uttar Pradesh has been installed at site to manufacture cement for the construction of the dam. The power project is expected to be completed in about five years.

At the rate of 2.4 pies per K.W. hour i.e. Rs. 104/8/- per K.W. year the cost of power comes to $\frac{20,000 \times 2.4}{16 \times 12}$ or Rs. 250/- per ton of aluminium produced. It is also possible that by negotiating with the Government, the power cost for the aluminium industry may be further reduced. It is important to note that each reduction of Rs. 10/- per K W. year in the power rate, would reduce the cost of production of metallic aluminium by Rs. 25/- per ton. Almost 25000 K.W. of power at 95% annual load factor are required for a 10,000 ton aluminium smelter.

ECONOMIC CONSIDERATIONS

The economical production of aluminium from bauxite requires a study of outstanding industrial investments, operations, and principal factors involved where economy can be effected.

TRANSPORT

It should be aimed at to find a bauxite deposit, a coal mine, and hydro-electric power all within a radius of 100 miles or so from the location of a plant to minimise the freight expenses. An abundant supply of water low in lime and magnesia must be also available.

Power is most important single item to be considered as regards the location, though it is possible to locate the reduction plant as far as 100 miles or so from the power station. However, the cost of transmission including the cost of power lost in transmission must be weighed against the cost of transporting raw materials to the source of power.

It may be freely admitted that the location of an aluminium manufacturing plant is a matter of freight charges ; but not as is commonly assumed, of freight on raw materials only. Obviously there must be included the freight on finished products to the point of consumption. To produce one ton of aluminium it is required to move about 7 to 9 tons of raw materials. A slight increase in the transport charges, therefore, means an increase of so many times per ton of aluminium produced. Transportation is one of the decisive factors in determining location of alumina plant. Bayer process can be operated successfully if the plant has excess to low freight rates to bauxite, fuel, soda ash and quick lime. For any given alumina plant location, the cost of transporting to the plant in large weights of raw materials must be considered with and against the cost of transporting alumina to the reduction plants.

Transportation charges in India are still an handicap to the development of the industry. It could be clearly visualised from the difference in freight rates charged in India and Canada. It would be of interest to know that the ingots produced at Alwaye, while being transported to Belur a distance of about 1500 miles are being charged for freight at the rate of Rs. 82/12/- per ton. at a preferential rate. Obviously this means an addition of Rs. 82/12/- per ton to the cost of ingots received by the consumers. In Canada the freight rate from the big smelting area at Arvida (Quebec) to Vancouver (British Columbia), a distance of about 3000 miles is 19 dollars or Rs. 90/8/- per ton. The Indian freight rate is much too high and a drastic reduction in freight charges on raw materials and finished products is desirable.

The distances over which raw materials have to be moved must be minimised. It would be essential to locate the plant near about the centre of bauxite and coal mines, which form about 5/6 of the total weight of raw materials to be transported. In addition, plenty of cheap power must be available at a reasonable distance. It is always beneficial to locate the plant in small community where the building costs could easily be much less than in a city. Labour would be also available cheap at a plant far away from a big city. Advantages can be taken of larger site, that would be possible with cheaper land, to provide for recreational facilites, better living and working conditions etc. for labour. For faster movement of goods a non-congested neighbourhood should be preferred. The aluminium industry is often driven to wilderness in most cases, to find location at which power can be developed or obtained cheaply enough and cannot be sold at a higher price to other industries. But it must be considered that in remote localities it is usually necessary to build and operate townships, as well as plants, and such "town site expense" is no small amount of the burden to be carried by the industry. A location near or on the bank of a river is usually recommended for it is easy to secure water supply for the plant and the waste water can be disposed of easily.

PROPOSED PLANT LOCATION.

Considering all the outstanding industrial factors involved for economic extraction of aluminium from bauxite, the proposed integrated plant should be installed at Anuppur in Central India. The other proposal may be to manufacture alumina at Anuppur and transport it to the reduction plant near Rihand Dam site to produce aluminium as well as finished products.

Anuppur is a small town situated on the bank of river Sone. It is the only railway junction on the Katni-Bilaspur section of Eastern Railway, and lies at a distance of 104 miles from Katni and 94 miles from Bilaspur by rail.

Anuppur offers a singular site for the location of alumina plant. It is hardly at a distance of 31 miles from Pendra Road. A scheme for the development, mining and transport of bauxite from the Amarkantak plateau has already been proposed. It would be loaded at Pendra Road station into Eastern Railway wagons and transported to Anuppur. A small railway siding or a trolley line can be extended for delivering the bauxite received at Anuppur station to the plant which may be located somewhere on the bank of river Sone. It has been estimated that bauxite could be delivered at Pendra Road station at Rs. 19/- per ton. The Railways will charge freight rate of Rs. -/2/5 per maund of bauxite from Pendra Road to Anuppur, Rs. -/5/9 per maund of limestone from Satna, Rs. 1/12/- per ton of coal from Burhar, Rs. 2/14/- per ton of coal from Birsinghpur and Rs. 3/7/- per ton of coal from Umaria to Anuppur. It may be possible to obtain special concession in rates when industry is started.

The coal supplies may be received from any of the nearby collieries preferably from Birsinghpur which is at a distance of 49 miles only from Anuppur.

It may not be possible to erect the caustic soda plant, as suggested' in the very beginning and therefore estimate has been based upon imported caustic soda.

The Sone river would provide sufficient water for the plant requirements. The village of Anuppur is at a distance of about 90 miles from the Rihand Dam site and erection of transmission line will have to be undertaken by the power authorities. It is considered well within the limits of the modern long distance power transmission possibilities.

The reduction plant must manufacture electrode paste for its own use. The raw materials, petroleum coke will have to be obtained from Digboi and pitch from the coalfeld and the same problem will have to be faced by a plant located anywhere else in India. Similarly imported cryolite, synthetic or natural, will have to be imported.

The proposal takes into consideration an initial unit producing about 10,000 tons of aluminium per annum, However, sufficient provision must be made, while designing the plant, so that the production capacity can be expanded to double or treble the erected capacity. This would make it possible to increase the production, and, consequently, a decreased cost of production in larger plant, when there be a need under stress of war or increase demand of metal by the peace time market.

The minimum economic capacity for an aluminium plant in India is considered to be 20,000 tons per annum. It should be therefore planned from the outset that the 10,000 tons initial capacity plant is capable of being integrated into greater unit under single management to produce about 20,000 tons when expanded. Cost of production in the initial 10,000 ton plant will be higher, however, development in two stages may be at present necessary considering existing possibilities of sale, future demand of the metal aluminium and finance available for the project.

COST OF PRODUCTION OF ALUMINA AT ANUPPUR.

To produce one ton of alumina it will require about 2 to 2.5 tons of bauxite to be treated by the Bayer process. Bauxite will be available at Pendra Road at a cost of Rs. 19 per ton and 2.5 tons of it would cost Rs. 47/8/-. It will be transported to Anuppur by rail. The Eastern Railway charges freight at the rate of Rs. 0/2/5 per maund or about Rs. 5 per ton.

For each ton of alumina about 0.14 ton of caustic soda would be required. Imported caustic soda may cost about Rs. 600 per ton.

About one ton of slack coal will be required per ton of alumina produced. It could be available at Rs. 16 per ton at plant site.

Roughly 0.25 ton of fuel oil will be consumed per ton of alumina and the cost of fuel oil being about Rs. 150 per ton, it would mean an expense of about Rs. 40 per ton of alumina recovered.

Other miscellaneous expenses, administration, labour, etc, have also been reckoned. An estimate on the cost of production of alumina is indicated in Table IV.

The total cost of producing alumina at Anuppur would approximately come to Rs. 370 per ton.

Table IV.

COST OF PRODUCING ALUMINA AT ANUPPUR SITE

Cost items.	Cost per ton of alumina.
Bauxite, 2½ tons at Rs. 19 per ton[a]	Rs. 47-8-0
Freight charges at Rs. 5 per ton[b]	12-8-0
Caustic soda, 0.14 ton at Rs. 600 per ton[c]	84-0-0
Slack Coal, 1 ton at Rs. 16 per ton[d]	16-0-0
Fuel Oil, 0·25 ton at Rs. 150 per ton[e]	37-8-0
Supplies, consumable stores, maintenance & repaires.	47-8-0
Wages.	22-0-0
Depreciation on plant and other block.	70-0-0
Administration and other expenses[f]	33-0-0
Total	Rs. 370-0-0

[a] Bauxite received from Pendra Road railway station by rail.

[b] Eastern Railway freight charges on bauxite being Rs. 0/2/5 per maund or about Rs. 5 per ton.

[c] Caustic Soda—imported.

[d] Coal from Birsinghpur or Umaria.

[e] Fuel oil imported.

[f] Administration etc. includes taxes, insurance, laboratory and control costs, staff, and other costs but excludes interest.

PRODUCTION OF ALUMINIUM AT ANUPPUR.

The reduction plant at Anuppur would be supplied power from the Rihand Dam. The cost of power generated at Rihand Dam is expected to be about 2.4 pies per unit. A 90 miles long transmission line may cost nearly Rs. 36,00,000 to Rs. 45,00,000 in its erection. Depreciation, interest, maintenance and supervision etc. are some of the other factors to be considered. Some power is always lost in transmission of electricity from one place to another. There would be a loss of about 2% of the power transmitted in the step-up-transformers at the generating stations. The loss of power during transmission is nearly 15 to 20%. The high tension transmission lines supply power at a high voltage which has to be stepped down and the incoming alternating current must be converted to direct current for use in the pot rooms. The loss of power in transformers, rectifiers and during transmission etc. has been taken to be about 25%. The cost of power supplied at Anuppur is computed in table V below :

Table V.

COST OF ELECTRIC POWER AT ANUPPUR

Cost of erecting the transmission lines, 90 miles long at Rs. 40,000 to Rs. 50,000 per mile, will come to about Rs. 36,00,000 to Rs. 45,00,000

Depreciation at 2%	....	Rs. 1,00,000
Maintenance and Supervision at 1%	...	50,000
Interest at 5%	....	2,50,000
Total cost per year	...	Rs. 4,00,000

A plant producing about 10,000 tons of aluminium per year would require a continuous supply of about 25,000 K. W. of electrical energy. Therefore the cost of electrical transmission would come to about $\frac{400,000}{25,000}$ or Rs. 16/- per K. W. year. Reckoning a total loss of 25% power during transmission and conversion etc., would mean that about $\frac{2.4 \times 25}{100}$ or about 0.6 pie per unit must be added to the cost of power. Besides, we must add Rs. 16 per K. W. year i.e., about 0.35 pie per K. W. hour, to the cost of power. It can be therefore assumed that power will be available at Anuppur at about 3.35 pies per K. W. hour.

To produce one ton of aluminium about 1.92 to 2 tons of alumina are required. The price of alumina produced at the alumina house has been estimated to Rs. 370 - per ton (Table IV).

The cost of manufacturing electrode pastes for Soderberg Continuous Electrodes would come to about Rs. 130 to 150 per ton of aluminium produced.

About 0.05 to 0.07 tons of cryolite (including fluoride) is consumed per ton of aluminium produced. The cost of cryolite being about Rs. 650 per ton, it would cost about Rs. 45 for each ton of aluminium.

The labour charges, taxes, insurance, interest etc. must be also considered to reckon the cost of producing aluminium. Table VI shows the estimated cost of aluminium produced at Anuppur.

Table VI
COST OF PRODUCING ALUMINIUM AT ANUPPUR

Cost Items	Cost per ton of aluminium.
Alumina, 2 tons at Rs 370 per ton[a]	Rs. 740-0-0
Electric Energy, 22000 K. W. hour at 3.35 pies per K. W. hour[b]	405-0-0
Carbon paste, 0.6 ton[c]	140-0-0
Cryolite and Fluoride, 0.07 ton[d]	45-0-0
Labour, direct and Supervisory	55-0-0
Pay roll, taxes, and industrial insurance	50-0-0
Miscellaneous cost	45-0-0
Total Direct Costs	1480-0-0
Maintenance, Depreciation on plant and other block[e]	200-0-0
Administration and Selling costs	50-0-0
Total overhead costs	250-0-0
Total cost per ton of aluminium	1730-0-0

[a] Alumina, see table IV

[b] Electric Energy, cost calculated in the text,

[c] Carbon paste, at Rs 140 per ton of aluminium manufactured at the plant.

[d] Cryolite and Fluoride, at Rs 650 per ton.

[e] It does not include interest on investment.

About 25% of the production of the plant may be sold in the form of virgin aluminium ingots and the remainder of 75% worked into semi-finished products such as sheets and circles in an adjoining fabricating plant. The cost of rolling pig aluminium may come to about four to five annas per pound of ingot fabricated.

ALUMINIUM REDUCTION PLANT AT RIHAND DAM SITE

An alternative proposal could be the location of the aluminium reduction and fabrication plant near the Rihand Dam site, utilising the alumina produced at the Alumina house at Anuppur. The alumina would be transported from Anuppur to Rihand site via Katni. The freight charges on alumina will have to be taken into consideration for a distance of approximately 350 miles. These expenses must be weighed against the cost of transmission of electricity to the reduction plant at Anuppur.

It is expected that power will be supplied to the reduction plant near the Rihand Dam site at the rate of 2.6 pies K. W. hour. The cost generating power being 2.4 pies only, and additional cost of 0.2 pie has been taken to balance for the power losses etc.

The estimated cost of producing aluminium at Rihand Dam site has been computed in Table VII

Table VII

COST OF PRODUCING ALUMINIUM AT THE RIHAND DAM SITE

Cost Items	Cost per ton of aluminium
Alumina, 2 tons at Rs. 370 per ton[a]	Rs. 740-0-0
Transportation charges from Anuppur to Rihand site, 350 miles	40-0-0
Electric Energy, 32000 K. W. hour at 2.6 pies per K. W. hour	300-0-0
Carbon paste, 0.6 ton[b] ...	140-0-0
Cryolite, 0.07 ton[c] ...	45-0-0
Labour, Direct and Supervisory ...	55-0-0
Pay roll, taxes and industrial insurance ...	50-0-0
Miscellaneous costs ...	45-0-0
Total Direct Cost	1415-0-0
Overhead costs	
Maintenance, Depreciation on plant and other block approx[d]	200-0-0
Administration and Selling costs ...	50-0-0
Total cost per ton of aluminium	Rs. 1665-0-0

[a] Alumina, See table IV

[b] Carbon paste, manufactured at plant, at Rs. 1401- per ton of aluminium.

[c] Cryolite and Fluoride at Rs. 550 per ton.

[d] It does not include interest on investment.

CONCLUSION

There are numerous advantages of establishing the aluminium industry in Central India. The extensive reserves of good grade bauxite on the Amarkantak Plateau have proved to be effective for the production of aluminium. The two other raw materials required by the industry—coal and limestone—both occur in the vicinity of bauxite deposits (Fig. 2). The availability of abundant supply of extremely cheap power at short distance from the Rihand Hydro-electric project offers the advantage in search of which bauxite has to be transported over long distances in other countries.

The broad gauge railway communication and the connection of the plant sites with the other market centres is advantageous so far as the availability of raw material or disposal of the finished goods is concerned. A centrally located plant will be at equal distance from all parts of India. Easy supply of products to the consumer at any part of India would be an extra advantage.

Besides these, plentiful supply of perennial river water, ample land, abundance of cheap labour and good climate make the plant in Central India ideally located for production.

Aluminium is metal of strategic importance. The established industry in Central India would be equi-distant from all the possible war fronts and therefore offers least danger of being first taken up by the aggressor.

Another point to be mentioned is that deposits of high grade dolomite occur in the area of the Transition (Pre-Cambrian) rocks around Jhapi, Ekpie and Amadari and Karund, between 16 to 18 miles west of Umaria, i.e., about 70 miles from Anuppur. This dolomite may be easily treated by the well developed Dr. Pidgeon's Process of extracting Magnesium from dolomite on a commercial scale. The Dominion Magnesium Company, Haloy, Ontario is operating this process very successfully. The development of the manufacture of magnesium near the aluminium plant could possibly lead to the establishment of a 'Light Metal' alloy industry so vital to the aircraft industry.

The 'light metal age' is definitely dawning in India. Our industrial civilization is expected to move at a very rapid rate. India will use aluminium to a considerable extent, as a substitute for one or more metals. Aluminium now promises to win its spurs in its own right by assumption of a major role in the commercial life. It would be fair to assume that India's per capita aluminium consumption would increase at an accelerated rate. Industries are developing which will depend upon the unique properties. The prospect of its increasing importance in economic progress can be visualized. Our country will demand more of aluminium, and aluminium will have a prosperous future, but generally speaking, the future of metal aluminium will not only depend upon how much we can produce but at how much minimum cost it can be produced or made available in India.

EXPLANATION OF FIGURES

Fig 1. Geological map of Amarkantak area

Fig 2. Map of Central India showing occurrences of bauxite, coal and limestone.

Fig. 3. Amarkantak reddish, ferruginous bauxite showing the pisolitic structure The kernel and periphery are usually ferruginous with a white aluminous body (½ natural size)

Fig. 4 Amarkantak bauxite showing pisolitic structure. (Natural size)

Fig 5. Micro-structure of Amarkantak bauxite. Pisolites with oolitic matrix. Yellowish brown pisolite embedded in amorphous matrix. Pisolites are traversed by irregular cracks filled with a net work of crystalline gibbsite. (×50)

Fig. 6. Photomicrograph showing a nest of intergrown crystals of gibbsite showing twinning effects. Crystalline gibbsite occurs in an amorphous matrix of cliachite, (Crossed niclos. ×50)

Fig. 7. Photomicrograph of pisolitic bauxite showing well developed oolitic pisolites and crystalline matrix. (Crossed nicols.)

Fig. 8, Micro-structure of a pisolite showing irregular cracks in a matrix of amorphous material. (×50) (Reflected light)

Fig. 9 Same specimen as in figure 8 (Crossed niclos.) showing crystalline gibbsite in cavities and cracks. (×50)

Photo by—Author.

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By

Mr. M. K. RAY & Prof. N. N. CHATTERJEE

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MINING LEGISLATION*

BY
Mr. M. K. RAY & Prof. N. N. CHATTERJEE

ABSTRACT

In the paper the authors have pointed out the serious defects and drawbacks in the Indian Mineral Concession Rules (1949) in connection with the mineral exploration work. Some of the rules as modified are found to be self contradictory, several are found to be highly discouraging to the explorers. Unless the rules are properly framed and unless security and assurance are given to the enterprisers in the field of mineral discovery and exploration work it is very doubtful if people will come forward to invest money in mineral exploration work and consequently healthy growth and development will not take place in this direction The Government should form a small committee to take a stock of the situation in the various states about the granting of prospecting license and mining leases since the independence and should do the needful in the matter of modification of the rules. Unless the mineral exploration is encouraged in the country it is not understood how the industries will flourish depending on mineral resources for rapid industrialisation of the country in the five year plans

About interpretation of the rules the State governments should not be given any hand in the matter but the Centre, the framer of the rules, should always give the correct interpretation.

In the present paper an attempt has been made to focus the attention of the Central Government and the public to the serious defects and shortcomings in the Mineral Concession Rules, 1949, as modified to date. These Mineral Concession Rules really control the people who come forward to invest money in the matter of mineral exploration and development work. Unless the rules are properly modified and amended and become encouraging to the enterprising people in this line it is very doubtful if the situation will improve much to create a more healthy atmosphere in the mineral exploration world of today. It is admitted on all hands that industrial development of a country depends much on the growth and expansion of mineral exploration work.

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* Read before the coal symposium held on 8. 8. 55.

The mineral development depends on the result of discovery of workable mineral deposits and such discovery is not invariably or even generally done by the Geological Survey of the country or the geological experts but often done by other laymen who have some enterprise to look for peculiar and unusual minerals or rocks in the field. After good amount of labour and expenditure the mineral deposits are discovered and it is quite natural to expect that the discoverer will get the mining lease of such deposits. These persons should be encouraged and as a matter of fact are encouraged by almost every country of the world. Such persons applying for mineral concessions should have right for getting such grants. After the discovery the deposits should be developed with the help of the experts and technicians.

If by the provision of the rules the discoverer is deprived of his rights of obtaining mineral concession of the areas then he loses all incentive and thus hampers the development of mineral industries.

Grant of mineral concessions in India are being regulated by the Mineral Concession Rules, 1949. The Mineral Concession Rules are made on the strength of the powers derived from Mines & Minerals (Regulation & Development) Act, 1948 (Act LIII of 1948).

During the last few years since these Rules have been enforced, it has been experienced that these Rules have not only failed to encourage development of new mineral deposits but have caused some discouragement. Amendments have been made from time to time, but many of these amendments have made the position even worse. The main defect in the Rules is that it gives wide discretionary powers to the officers of the State Governments granting mineral concessions. As is very well known, corruption and ill practices do prevail in our country and if wide discretionary powers are given to officers, they are apt to be misused, particularly in view of the fact that mineral properties are usually of immense value. The effect of discretionary powers has often been found to be very unsatisfactory and partial, causing undue hardship on the bonafide parties in this mineral exploration work. Unless something is done to stop these ill practices, we can hardly expect a healthy growth in our Mineral Industry.

Even when the provisions of the Mineral Concession Rules are quite clear, the officers are sometimes tempted to violate the provisions and act in an arbitrary manner and there is no provision in the Mineral Concession Rules to check these arbitrary acts of the officers. They may, if they like, ignore the claims of the first applicant for mineral concessions and grant to a subsequent applicant in violation of Rules 18 and 32 of the

M. C. Rules. They may as well refuse to grant a mining lease on some false pretext to holder of Prospecting license by recording some vague reasons for such a refusal. They may keep applications for Certificate of Approval of Prospecting License or Mining Lease pending for several years for obvious reasons. And if pleased, they may grant a renewal of Mining Lease even if there was no Mining Lease existing and no proper application for renewal was made. Complaints made against these officers are simply ignored, and actions against these officers are never taken. Even if such cases are brought to the notice of the Central Government, the Central Government can only request the same officers to expedite disposal of the cases but can not do anything beyond that. The Minister in charge of N. R. S. R. admitted the other day at the last meeting of the Mineral Advisory Board held at Srinagar that he knew of cases pending for years and years but was powerless to do anything in the matter. This ultimately means that the complainant has to suffer great prejudices in the hands of those officers complained against. There have been cases in which inordinate delays caused by officers of State Governments were brought to the notice of Central Government. The Central Government requested State Governments several times to expedite disposal of the cases and pass early orders on the same. All these requests went and inspite of repeated reminders, more than once State Government did not care to give any reply for about a year. Thereafter, the officer in one instance having been annoyed with the complainant did not grant him the area but granted the same area to another party clearly in violation of Rule 18 of M. C. Rules, and yet, when the matter was brought to the notice of the Central Government, in "Review" petition, the Central Government declined to interfere in the matter as according to Central Government, the State Government had discretionary powers. Such cases can only bring frustration in the minds of the first applicant, the discoverer of a deposit and naturally discourage search for new areas.

If an officer wishes to ignore the prior rights of the first applicant and grant the area to any other applicant without any special reason and without obtaining any prior approval from the Central Government, all that he has to do is to reject the application of the first applicant under Rule 17 of M. C. Rules which is alleged to have given absolute discretionary powers and then grant it to an applicant of his own choice.

In order to grant mineral concessions to such persons who have discovered such minerals there is a provision in the Mineral Concession Rules, 1949 (Rule No. 16) where entry has to be made about the date and time of application for such concession. The wording of the rule definitely indicates that the first applicant should have right against late comers for the same area. The very next rule (Rule No. 17) makes a complete nonsense of the provisions of Rule 16. The Rule 17 says the "State Government may grant or refuse the license." The legal implication of this statement is that the first applicant has no right at all and he can have no say in the matter if the State Government grants the same area to another party. This definitely shows that a discoverer could be deprived of the fruits of his enterprise and honest labour. This shows that the State Government has been given full power to grant or reject applications from persons discovering mineral properties. Though there is a provision of review (Rule 57) by the aggrieved party to the Central Govt. against the award by the State Government the Central Govt. cannot stop the State Govt. from granting the mineral property under review to another party. If the Central Government cannot prevent the State Government from making such grants the question of review becomes meaningless.

Re: INTERPRETATION OF RULES.

The interpretation of rules should always be made by the Central Government otherwise the different States may make different interpretations for the one and the same rule. For example, Rules 24 and 25 may be cited. Regarding Rule 24, the licensee has been given the right to get the lease which right has been taken away by the proviso under the same rule. As the proviso is contradictory to the rule it should be deleted otherwise the right under the rule becomes meaningless. In the 2nd meeting of the Mineral Advisory Board held at Ranchi in 1954, the Board adopted a resolution about the deletion of the proviso under Rule 24 and the Government agreed to consider the matter and find the way of removing the objection. But at the last meeting held at Srinagar in 1955 the Secretary N. R. S. R had to admit that the Central Government had done nothing in this matter during the intervening period of one year. The prospectors always invest money and energy with the idea of obtaining mining leases and unless there is a definite guarantee of mining lease the grant of prospecting license has no meaning and the prospectors will not come in the picture of mineral exploration and development. Rule 25. In many states the interpretation of this rule is made in such a fashion demanding the prospecting report before the grant of mining lease whereas the commonsense interpretation of the rule definitely shows that the report shall only be submitted within a year of the grant of mining lease i. e. after the grant of mining lease. It stands to reason that the confidential information regarding the result of prospecting should not be divulged before his right of mining lease is secured.

The interpretation of the rules should not be left to the State Government but should only be done by the Central Government who are the framers of these rules.

It may be pointed out in this connection and for the smooth working of the rules that the rules should always be framed and worded in such a way that the interpretation becomes very easy for a common man leaving no room for any ambiguity and mis-interpretation. If however any question arises regarding meaning or interpretation of any rule the Central Government should give a direction or ruling in such matters. This will avoid litigation which is always expensive for the parties concerned. If the party has to seek the help of the law courts for interpretation of rules every now and then, then the matter becomes very expensive and highly discouraging for the mineral explorers.

Another serious defect in the M. C. Rules is that there is no provision of any appeal against the orders passed by State Government except in cases of (1) Refusing to grant Certificate of Approval, Prospecting License or Mining Lease or refusing to renew Certificate of Approval (2) cancelling Mining Lease or Prospecting License and (3) Refusing to permit transfer of Prospecting License or Mining Lease.

There is no provision of being represented by a Counsel before Central Government and no hearing of any kind is allowed. There is no provision for any appeal in any Court of Law against the "Review" order passed by Central Government except by an application under Art. 226 of Constitution of India before High Court for issuing a writ in the nature of Mandamus or any other appropriate writ. But, it is usually difficult to get these applications admitted and are rejected even without a proper hearing as an application under Art. 226 is not like a regular Appeal. There is no provision of an appeal before Supreme Court except under Art. 136 of Constitution of India i. e. Special leave to appeal by the Supreme Court. All these difficulties mean that the aggrieved parties have practically no redress.

In view of the facts mentioned above, the following amendments in the Mineral Concession Rules become absolutely essential :—

Rule 17 (1) should read as follows :—

"Subject to the provisions of Rule 13, the State Government shall grant License to the first applicant having prior claim under Rule 18, if the land is available for grant.

In case, the land is not available for grant, all the applications for that area shall be rejected and the area shall not be granted to any subsequent candidate."

Rule 18.

The Proviso added by Notification No. MII-152 (103) dated 29. 7. 53 should be deleted.

(Unless the proviso is deleted, there will always be the danger of discoverer not getting the area as it is easy for influential parties to obtain information from the office concerned and then to submit an application on the same date and for the same area).

Rule 24.

The Proviso added by Notification No. MII-159 (10) dated 7. 11. 51 should be deleted.

(Unless the Proviso is deleted, there is always danger of mischief after the area is proved to be of great value. This Proviso makes Prospecting License completely meaningless).

Rule 32.

The Proviso added by Notification No. MII-152 (103) dated 29 7. 53 should be deleted.

(For same reasons as given in 18).

Rule 51 & 53.

There should be similar Rules in case of Grant by Government.

(These Rules provide for punishments in cases of grant of Prospecting License or Mining Lease in contravention of M. C. Rules against private persons only but there is no parallel provision against similar acts of officers of State Governments. It is a fact that some State Governments are openly charging Royalties at rates double than those fixed by Central Government. It is not understood as to why Central Government is not taking serious action in the matter. For Example Orissa Government has been charging Royalty for Manganese ore at the rate of 10% of Pit's mouth value although only 5% should be charged according to M. C. Rules. If positive measures are provided for violation of rules by private persons, the same measures should be equally applicable to the officers of the State Governments for similar violation.

Rule 57 (1) should read :

Any persons aggrieved by any order of a State Government in connection with M. C. Rules, may within two months of the date of such orders apply to the Central Government for reviewing the same.

Rule 60.

There should be provision of an appeal against the orders of Central Government before Supreme Court.

The attention of the country's National Government is drawn to these defects and drawbacks in the Mineral Concession Rules (1949), and it is hoped that these comments will be carefully considered by the relevant authorities for proper amendment of the existing rules. It is the desire of every one of us that the Mineral Concession Rules should always be helpful and give encouragement to the prospectors to take more active interest in the matter of mineral exploration work which would lead to more healthy development of mineral deposits and consequent rapid industrialisation for the good of the country and its people.

We may conclude by quoting what our Society suggested in 1951 about these rules: "The Society has all along been suggesting to the India Government that there should be uniformity in the rules and regulations regarding exploration, prospecting and extraction of mineral deposits in the different parts of the Indian Union and for this purpose India should be considered as a single unit devoid of provincial barriers because Geology knows no political boundary. Such steps if taken even now will certainly create a healthy atmosphere in the prospecting and mining world. The India Government should not allow the Provinces to have too much autonomy in the matter of mineral development except in the matter of execution of rules and regulations framed by the Central Government. The Society also suggested on many occasions that the subject of mineral development should rest exclusively with a portfolio of the Central Government and not with the Provincial Governments."

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By

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ON CERTAIN MINES, GEOLOGICAL AND MINING INSTITUTIONS AND FACTORIES IN JAPAN*

BY
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Superintending Geologist, Geological Survey of India.

I. INTRODUCTION

The Government of India kindly permitted me to spend a short period in Japan to visit certain mines and institutions, after the termination of the ECAFE conference in Tokyo from 15th to 24th March, 1955. During the period, the author visited several geological departments and institutions and certain metalliferous mines, mills, smelters, refineries, factories, etc., and held discussions with several top-ranking Geologists, Mining Engineers and Metallurgists of Japan. It has thus been possible to obtain some detailed information and a large amount of data in a comparatively short time. It is hoped that these notes will be of some help to the members of the Geological, Mining & Metallurgical Society of India.

My grateful thanks are due to Dr. T. Watanabe, Prof. of Economic Geology, Geological Institute, University of Tokyo, for kindly drawing up my tour programme and arranging visits to the mines, geological institutions, etc. I am also thankful to the Directors of the Mitsui Mining & Smelting Co., Ltd., and the Nippon Mining Co., Ltd., for the excellent arrangements for the trips to their mines.

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* Published with the kind permission of the Director, Geological Survey of India
Read before the Society on 6. 7. 56

My thanks are also due to the Directors of the Geological Survey of Japan, the Mining & Metallurgical Research Laboratory of Mitsubishi Metal Mining Co., Ltd., and the Resources Research Institute, for facilities to visit the respective institutions. My indebtedness to the management of the factories visited, for taking me round their works, is also gratefully acknowledged.

The industrial progress of Japan in recent has been largely due to the application of modern scientific knowledge in various fields of science and industry. The important role played by Geologists, Mining Engineers and Metallurgists in the scheme of things in the country has been significant. In Japan geological researches are undertaken not only by the Government Departments and Universities, but also by several mining companies, who follow up-to-date methods of geological exploration with the assistance of trained Geologists. Recent advances on methods of mineral exploration and improved techniques on ore-dressing and metallurgy have brought about correct appraisal of mineral deposits and greater recovery of various metals as by-products from a single ore body, hitherto rejected as mine dumps or lost as waste tailings.

The **ton** referred to in this paper is the metric ton of 1,000 kilograms. The Indian Rupee is approximately equivalent to 75 Yens.

Japan like other industrial nations has become a greater consumer of minerals, as the country's progress depends on the supplies from foreign source with respect to minerals she is deficient.

II. KAMIOKA LEAD-ZINC MINES

Introduction :—Located in the main island of Japan, at the West coast, the Kamioka mines lie in the mountainous region commonly known as Japanese Alps and are reputed to be the largest lead-zinc mines in the country. During the time of my visit remnants of snow were seen all along the mining area.

Opened about twelve centuries ago for working gold and silver, the mines were developed on a large scale about three hundred years ago with the object of winning only lead and silver by primitive cupellation process, without paying any attention to zinc ore. In 1886 the Kamioka property was taken over by the famous house of Mitsui and the European lead smelting practice was adopted, and subsequently with the gradual industrialisation of Japan, the production of lead in 1943 rose to a maximum of 20,000 tons. The mines have also yielded about 48% of Japan's total production of zinc since 1925.

Prior to World War I, zinc concentrate was wholly exported to Germany or Belgium for smelting and refining as there was no zinc smelter in Japan. Refining of zinc was first introduced by Mitsui Mining Co., Ltd., in 1914, at the zinc smelter at Miike in Kyushu, and the industry stabilised itself with further industrial progress of the country. Most of the zinc was produced by distillation till 1943, and subsequently both electrolytic and distilled zinc were produced in the country. The electrolytic producers of zinc follow the practice employed in the U. S. A.

The Kamioka property was till recently worked by the Kamioka Mining and Smelting Co., Ltd, which in 1952 was styled as the Mitsui Mining and Smelting Co., Ltd. The company owns 20 kilometres of private railway from Inotani Railway Station. The zinc concentrate from Zawar mine is smelted in one of the smelters of the company.

Reputed to be one of the most important metal mines in Japan, equipped with modern mining machinery and up-to-date ore dressing plants and floation units, and undertaking electrolytic lead refining by Betts process, electrolytic zinc refining by Tainton process, production of H_2SO_4 by Monsanto contact process, and recovery of gold, silver, bismuth and cadmium, it is considered to be the most progressive mine in the country.

Some quantity of graphite is also recovered from the smelter and refinery at Kamioka. Graphite, in small amount, is known to be present in skarn and also in ore, and indicates remnants of original graphite in the mineralised limestone.

Custom ore, i.e., ore purchased from two neighbouring mines, and Au-Ag-ore from Shimonomoto mine (20 miles from Tochibora) are also treated along with ore from Kamioka at the company's smelter and refinery.

General Geology :—The terrain is mountainous and forested, some of the peaks being 1,584 metres (near Shimonomoto), 1,368 metres (Mozumi) and 1,219 metres (Tochibora). The regional geology consists essentially of the following formations :—

(1) Hida gneiss :—It is partly or highly metamorphosed Palaeozoic sediment, with intercalated Palaeozoic crystalline limestone, amphibolite and skarn, striking N.–S. to N.N.E.—S.S.W. and dipping steeply. The gneissic suite mostly comprises biotite-hornblende to hornblende-diopside gneiss. It is partly para-gneiss, injection gneiss and ortho-gneiss, and represents metamorphosed basic and calcareous rocks formed as a result of regional metamorphism brought about by a batholithic granite. The Mozumi, Maruyama and Tochibora pits are located in this formation.

(2) **Granitic rocks** :—Linked to the batholithic intrusion, to the south and east of the region, the granitic rocks are of a late Palaeozoic to early Mesozoic age. The metamorphism of the Palaeozoic sediment is attributed mostly to the eastern granitic belt known as Shimonomoto granite. The other acidic derivatives of the granite are aplites, pegmatites and syenitic rocks. The southern granite belt is termed Funatsu granite, which is considered to be newer than the Shimonomoto granite. The granitic igneous activity is considered to be genetically linked to the ore deposits of the Kamioka mines.

(3) **Jurassics** :—The northern and north-eastern region is occupied by Jurassic rocks, unconformably overlying the Hida gneiss. The formation usually trends E.-W. The Shimonomoto gold-silver-lead veins are located in this formation.

The Yokoyama thrust fault, striking approximately W.N.W.-E.S.E. and dipping 30-60 degrees south-west, is the most important structural feature of the region, which is traceable for many kilometres through north-central Japan. The Hida gneiss and granite are thrust over the Jurassic rocks along this fault, resulting in mylonitisation of the gneiss as noted near Mosumi valley.

The trend of the pre-mineralisation fissures in the gneiss runs between N.-S. and N.E.-S,W., roughly in conformity to the foliation of the gneiss. The gneiss is characterised by a complex folding pattern, particularly by a series of steeply plunging isoclinal folds. A later series of E.N.E.-W.S.W. parallel faults, with almost vertical dips, cuts across the Yokoyama thrust fault. Movement along these faults has rendered the Yokoyama thrust fault into several segments, arranged **en echelon**, stepping down from north to south.

Ore Deposits :—According to Mr. C. Nishiwaki[1], they are mostly pyrometasomatic deposits in association with skarn rocks, partially or fully mineralised, occurring as irregular, highly inclined or vertical bodies formed along foliation planes, faults, fissures, etc. Such deposits constitute about 80% of the present production and ore reserves.

The skarn deposits are usually elongated parallel to the foliation plane of the Hida geniss, with steep inclined pitch, often preserving the pre-mineralisation folded structures indicated by the arrangements of different skarn minerals. The largest ore body (No. 9 deposit) is 260 metres long and 70 metres wide, the depth of mineralisation persisting beyond 500 metres below the surface.

Sphalerite and galena constitute the most important ores, the ratio of zinc to lead varying commonly between 5 : 1 and 10 : 1. Galena is argentiferous, one ton of lead concentrate (70% Pb) containing 2,500-3,000 gms. of silver. Besides, argentiferous tetrahedrite and schirmerite in microscopical amount are also present. Another most important accessory mineral is chalcopyrite occurring usually as microscopical patches or ex-solution droplets in sphalerite and galena. Small amounts of pyrrhotite, pyrite, bornite, arsenopyrite, magnetite and haematite are present. Minor traces of molybdenite, native bismuth and bismuthinite are also noted. The gangue consists of skarn minerals, e. g., diopside-hedenburgite, calcium garnet, minerals of epidote-zoisite series and wollastonite.

In case of mesothermal replacements or low-temperature deposits, over-lapping the pyrometasomatic deposits, tetrahedrite, native silver or jamesonite are noted in the skarn ore, along with quartz, calcite, ankerite and chlorite.

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[1] Nishiwaki, C, "Lead and Zinc deposits of Japan with special emphasis on those of the Kamioka mine, **Prcc, Seventh Pac Sc. Cong**, Vol 2, pp 234-244, 1953"

The pyrometasomatic deposits are primarily formed after limestone but also replace the adjacent gneiss, already metamorphosed, folded and faulted. The skarn masses appear to have been formed under definite structural control in fissured and folded Hida gneiss and associated limestone.

In Mozumi and in part of Tochibora mine, mesothermal replacement deposits, replacing limestone and skarn, and related to a later period of mineralisation, are noticed. The No. 9 ore body (Tochibora), showing further enrichment due to subsequent mesothermal replacement, is a good example. The mesothermal deposits are particularly more irregular and are controlled by fissures and shape of the pre-existing folded limestone. As in skarn deposits, they consist of sphalerite and galena, in addition to some chalcopyrite, pyrite, arsenopyrite, tetrahedrite, haematite, native silver and graphite. Mesothermal replacements while replacing limestone, contain as gangue quartz, calcite and other carbonate minerals, but while replacing skarn, chlorite and relict texture of hedenburgite are also seen.

In addition to the two types of deposits referred to above, another type of ore body of epithermal stage, i.e., fissure filling veins, is also recognised in Kamioka area.

The ore deposits in Kamioka region are believed to be linked to the late Mesozoic igneous activity.

A study on the structural control of Kamioka ore deposits by Mr. T. Iwafune, Chief Geologist, Kamioka mines, has shown the existence of an unique folding structure in each mining area, where the fundamental standpoints of structural considerations of ore deposits have been established, leading to the location of new ore bodies in prospective areas. The study has proved an anticlinorium at Tochibora, and a reversed S shaped structure like an overfold at Mozumi, where each ore bearing limestone bed or ore body is characterised by drag foldings. Maruyama shows repetition of drag foldings in an ore zone elongated from north to south. Generally the orientation of the main folding axes coincides with that of the drag foldings. The distribution of acidic derivatives of the granite, linked to the ore mineralisation, also controls the location of ore bodies.

Prospecting based on the structural control of ore deposits, by establishing the relation of folding and the plunge of ore body, has generally facilitated easy and accurate location of ore body and determination of its shape. Thus the most adequate stoping method in any proposed stope block can be decided upon in advance.

Mining :—Pb-Zn-ore is worked from three different mines, namely Tochibora pit, Mozumi pit and Maruyama pit.

The No. 9 deposit is the biggest and main ore body in Tochibora pit. The daily yield of ore from Tochibora is about 2,500 tons. The Mozumi mine produces about 420 tons of ore per day. The Maruyama pit with one 200-metre deep shaft and 7 levels, where four ore bodies are located was not worked during my visit. It is proposed to be worked very shortly.

While working the large deposits, ore is usually mined by overhand stoping and backfill, the fill originating from the surface. Due to the firmness of the country rocks, little timbering is done in the mines. The output per man per day is about 4.5 tons. Further mechanisation of mining and development and increase of ore production are proposed in the future programme of expansion.

There are five hydro-electric power plants owned by the company, with a total capacity of 9,650 kilowatts. Further expansion of the Kamioka power plants is being proposed for future developments.

Mills :—There are three mills in the area. The Tochibora plant has a capacity of 1,400 tons per day. The other two mills are located at Shikama and Mozumi and have a capacity of 11,000 tons per day and 440 tons per day, respectively. I visited the Shikama ore dressing plant.

The ore is conveyed from the mines to the Shikama mill. It is hand-sorted before and after preliminary crushing, and 10-35% of the waste is sorted out on a picking belt. Preliminary crushing is carried out in the first instance by Jaw crushers, and then by gyratory crushers and subsequently by cone crushers. The crushed ore is lead into ore bin (-10 mm. size).

The material from the ore bin is fed into the ball mills for final grinding, and thence to the classifiers, and eventually to the differential flotation system. The lead concentrate contains 70% Pb, the recovery being of the order of 88-92%. The tailings from lead concentrate, containing some zinc, are led to zinc flotation units for recovery of zinc. The rejected tailings contain 0.02% Pb. Altogether 700 tons of lead concentrate are produced every month.

The lead concentrate contains some graphite, which is further separated by flotation.

The zinc concentrate contains 59% Zn, the recovery being of the order of 95—97% The monthly production of zinc concentrate is about 6,000 tons. The tailings from zinc concentrate are led to the settling tanks for further recovery of zinc, the rejected tailings containing 0.1% Zn. The zinc concentrate contains 0.2% Cd.

Ore Reserve & Grade of Ore :—The Mitsui Mining and Smelting Co., Ltd., has a team of Geologists, Mining Engineers and Chemists, who are working unceasingly to explore and discover fresh ore bodies in its concessions. The up-to-date ore reserve of Kamioka mines and grade of ore are tabulated below :—

	Estimated Reserve (tons)	Grade			
		Au (Gram/ton)	Ag (Gram/ton)	Pb %	Zn %
Lead-zinc ore					
Tochibora pit ...	23,800,000	—	33.0	0.42	5.0
Maruyama pit ...	8,300,000	—	26.0	0.31	4.5
Mozumi pit ...	3,600.000	—	32.0	2.51	8.5
Gold-silver ore					
Shimonomoto ...	48,000	12.0	788.0	5.3	—

Smelting & Refining :—The following points with regard to the treatment of zinc concentrate may be mentioned :—

(1) 60% of zinc concentrate from the Kamioka mines goes to Miike smelter and Hikoshima smelter, only 40% of zinc concentrate being treated in Kamioka smelter.

(2) The composition of the waste or expelled gas ($S0_2$) from the roaster is as follows :—$S0_2$: 7%, 0_2 : 13% and N_2 : 80%.

(3) There are two converters to convert $S0_2$ into $S0_3$, using vanadium catalyst. H_2S0_4 is manufactured (98%) by contact process.

(4) The roasted product from the roaster, i,e , zinc oxide (calcine), contains 1.5% S.

(5) Zinc oxide is dissolved in H_2S0_4 to form $ZnS0_4$ in leaching tanks, etc., and impurities of Ni, Co and Cu are eliminated before electrolysis.

(6) The purified solution ($ZnS0_4$) is treated in the zinc electrolytic plant for electrolytic zinc (99.99% Zn) ; zinc deposits on cathode, an aluminium metal plate, the anode plate consisting of lead with 1% silver. The leaching from the zinc electrolytic plant residue is led into cadmium electrolytic plant for the recovery of electrolytic cadmium or sponge cadmium, which is further refined to 99.97% purity by electrolysis.

Some of the features with regard to the smelting of lead concentrate are indicated below :—

(1) The entire lead concentrate is treated at Kamioka smelter.

(2) Iron scrap and limestone and residue from the blast furnace are added to the lead concentrate in the roaster.

(3) The roasted lead concentrate is treated at the two blast furnaces whereby lead bullion or crude lead (97% Pb) is obtained.

(4) The waste gas from the blast furnaces is led to the dust collectors for the recovery of arsenic.

(5) The blast furnace slag, containing 10% Zn, is treated by electric furnace process for the recovery of Zn (98.52% purity) and Pb.

(6) Some copper as matte (25% Cu) from the blast furnace is recovered, the monthly production being about 15 tons.

(7) The lead bullion or crude lead is treated at the electrolytic plant for the recovery of electrolytic lead (99.99% Pb,), lead being deposited on cathode.

(8) The slime, i.e., anode from the lead refining plant is treated by the slime treatment plant for the recovery of refined gold (99.85% Au) and bismuth (99.97%Bi), and electrolytic crystal silver (99.99% Ag).

Production :—The various products at the Kamioka smelter and refinery are tabulated below :—

Product	% of metal	Designed monthly capacity	Average Monthly output
Electrolytic zinc	99.99	1,500 tons	1,500 tons
„ lead	99.99	600-650 tons	650 tons
„ silver	99.99	2,500 Kgs	2,000 kgs
„ bismuth	99.97	3,500 Kgs	2,150 kgs
„ cadmium	99.97	5 tons	5 tons
Refined gold	99.85	2 Kgs	2 Kgs
Sulphuric acid (98%)	—	2,500 tons	2,500 tons
Zinc dust (from slab zinc)	99.0	40 tons	30 tons
Graphite (90%C)	—	—	42 tons

III. HITACHI COPPER MINE

Introduction :—Located at the Pacific sea-board, about 100 miles from Tokyo, the Hitachi mine is one of the most important copper mines in Japan. It is a subsidiary concern of the Nippon Co., Ltd., reputed to be the largest copper producing company and a leading petroleum company in Japan, having under its control 32 mines, 3 smelters, 2 metal refineries and 1 petroleum refinery, the number of employees totalling 15,000.

The Hitachi refinery was destroyed during World War II. The mine has its own private railway from Hitachi Railway Station.

The main products of Hitachi smelter and refinery are electrolytic copper, electrolytic gold, elctrolytic silver, platinum, palladium, selenium, copper wire, bars, copper powder, copper sulphate, nickel sulphate and sulphuric acid. Hitachi refinery is equipped with a cathode melting reverberatory furnace having a monthly capacity of 2,000 tons of copper.

There are two Lurgi type contact acid plants for the manufacture of sulphuric acid, using vanadium catalyst, each with capacity of 100 tons (100% acid) per day. One plant, set up in 1939, obtains its source of sulphur from the roasting of pyrite, whereas the other, operating since 1951, utilises the waste gas from the copper smelter. The successful utilisation of waste gas in contact acid plant, the first of its kind in Japan, is conducive to the higher recovery rate of sulphur and decrease in the extent of atmospheric contamination.

Pyrite ore and copper concentrate are separated by flotation. The former is used for the manufacture of sulphuric acid, and the latter is treated at the smelter for blister copper, which subsequently goes to the refinery for the refining of copper and for the recovery and manufacture of various by-products.

Recent improvement in technique has been successful in lowering the grade of copper in the pyrite concentrate close to 0.1 per cent. in the mill, thus enabling the pyrite sinter, containing 55% Fe, to be used by the iron smelters. About 2,000 tons of pyrite sinter are sold every month to the iron smelters.

Geology :—Situated on the southern limits of the Taga mountain range, a part of the Abukuma plateau, the Hitachi mine lies in a Palaeozoic formation belonging to the so-called "Chichibu" system.

The Palaeozoic formation to the south comprises slate, sandstone, conglomerate and limestone, whereas to the north the rock types consist of epidiabase, amphibolite, amphibole-schist, sericite-schist, biotite-schist, chlorite-schist and various siliceous rocks. The Palaeozoic formation usually strikes N. E.-S.W. with south-easterly dip in the south, but dipping steeply while approaching north, where the strike eventually reverse its direction, i.e., trending N.W.-S.E.

Other important rock types to the north-east and north-west of the Hitachi mine, intruding into the Palaeozoic formation, belong to the granodiorite suite of igneous rocks. In addition, biotite-granite and periodotite are also noted in the region. Tertiary and Quaternary deposits cover the coastal areas to the east.

Ore Deposits :—The ore deposits belong to the Kieslager type of bedded, cupriferous pyrite deposits of Germany, and run as veins conformable to the foliation plane of the metamorphic rocks near the northern Palaeozoic zone. They occur as numerous parallel bodies in the form of complicated structures, the ore minerals consisting primarily of cupriferous pyrite (pyrite embedded in a cementing matrix of chalcopyrite) and some pyrrhotite and sphalerite.

Altogether about 60 important ore bodies have been located, which are broadly divided into seven groups, namely, Sasamo, Chusei, Kamine, Konko, Irishiken, Akasawa and Taksuzu. The characteristic features of the various groups are tabulated below :—

Groups	Strike	Dip	Number of ore bodies	Length (metre)	Width (max) (metre)	Width (av) (metre)	Depth (metre)	Cu% (av)	S% (av)	Types
Sasamo	N—S	70° W	11	150	45	8.5	150	1.2	25	Massive or irregular
Chusei	N45°E	80°NW	8	450	40	4.5	500	2.4	30	Massive or tabular
Kamine	„	70°NW	7	450	20	3.0	600	1.9	30	Tabular
Konko	„	„	5	300	20	2.5	600	1.8	30	Tabular or lenticular
Irishiken	N45°E	45°NW	4	150	20	2.5	700	3.5	30	Pipe like
Akasawa	N35°E	60°NW	11	450	80	6.5	500	2.1	35	Massive or tabular
Takasuzu	N—S	70°W	14	450	40	4.0	550	1.6	35	Lenticular or tabular

The ore bodies roughly cover an area, 2,000 metres long and 1,000 metres wide, the depth of mineralisation persisting beyond 650 metres below the surface. The ore bodies are very complicated in structure, being associated with a series of folded and faulted rocks, with conspicuous W. N. W-E. S. E. striking faults.

Prospecting :—The Nippon Mining Co. Ltd., has its own Prospecting Division, manned by well trained Mining Geologists, Geophysicists and Chemists. This Division is charged with the object of discovering fresh ore bodies, and conducts detailed geological surveys, geophysical surveys and geochemical surveys with a view to planning all future explorations.

Exploratory pits, trenches, cross-cuts, etc., assisted by a programme of diamond drilling, are being systematically carried out by the Prospecting Division. Eventually the ore reserves are calculated on a proper and scientific basis.

The Hitachi mine is known to have already raised 20 million tons of ore, equivalent to 300,000 tons of electrolytic copper, during the last 50 years. The average tenor of ore has been of the order of 1.5% Cu. The ore reserve, as assessed to date, is believed to be 10 million tons, with an average content of 1.1% Cu.

Mining :—The up-to-date underground working cover a strip, 2,500 metres long and 1,000 metres wide. There are altogether 11 shafts, but the present workings are limited to 4 shafts. The levels are 15 in number, generally 50 feet apart, the deepest important workings being located at 600 metres below the surface from No. 1 shaft, i. e., 250 metres below sea-level. The newest shaft (No.11) uses a skip hoist, which has three compartments (one for men and equipment, one for ore and one for fine ore).

The main sumps into which all underground mine waters are pumped are located about 200 metres above sea-level. The water is subsequently led into the sea by gravity.

The mine is equipped with up-to-date machinery, and has its own hydro-electric generating plant about 50 miles north of Hitachi, which yields about one third power requirements, the rest being bought from elsewhere. The total need at Hitachi is of the order of 6 million kilowatts per month.

The miners are provided with modern and sanitary houses and have excellent medical facilities and health insurance system. Fairly high standard of salaries and wages is maintained with provisions to guarantee retirement benefits to the employees.

Mill :—Located not far away from the mine, the dressing mill at Hitachi (Motoyama mill) has a capacity of 40,000 tons per month. The ore is brought by aerial ropeway to the mill. It is crushed, screened and ground, and the product passed on to the classifiers. Concentration is done both by heavy media separation using ferro-silicon as medium, and flotation. The products are separated as copper concentrate and pyrite concentrate.

The average composition of the ore mined, copper concentrate, pyrite concentrate and tailings from the mill is tabulated below :—

	Cu %	Au (gm/ton)	Ag (gm/ton)	S %
Ore mined	1.07	0.4	4	17.70
Copper concentrate	17.07	4.0	40	32.72
Pyrite concentrate	0.12	0.3	3	46.00
Old tailings	0.55	0.3	3	6.50
Tailings (for filling stopes)	0.09	0.2	2	1.96

The average monthly output of ore mined is of the order of 30,000 tons. The average output of copper concentrate and pyrite concentrate is 2,000 tons and 11,000 tons, respectively. About 10,000 tons of old waste tailings are also recovered every month for treatment.

Smelter :—It is situated about 3 kilometres south-east of the mill. It uses the following sources for smelting :—

(1) Ore from Hitachi (flotation concentrate) and cement copper (copper recovered from mine waters).
(2) Custom ore (ore purchased from elsewhere) both as lump ore and fine ore.
(3) Ore from other Nippon Mining Co. Mines.
(4) Copper scraps.

Coal and coke are used for the blast furnace. The waste gas is recovered for the manufacture of sulphuric acid.

Refinery :—Located about 2.5 kilometres south-east of the smelter, the refinery purifies or refines the blister copper from the smelter at the electrolytic refining plant. Other by-products at the refinery are electrolytic gold, electrolytic silver, chemically firened platinum, palladium, selenium, nickel sulphate and copper sulphate.

Production :—The various products from the Hitachi mine are as follows :—

Product	Grade or quality	Average monthly production
Electrolytic copper	99.99% Cu	1,800 tons
Selenium	99.90%Se	800 Kgs
Refined silver bars	99.99%Ag	1 ton
Refined gold bars	99.99%Au	100 Kgs
Platinum	99.98%Pt	1 Kg
Palladium	99.98%Pd	500 gms
Nickel sulphate crystals	21.6%Ni	10 tons
Copper sulphate crystals	25.6%Cu	150 tons
Powder Copper sulphate	25.6%Cu	
H_2SO_4(98%)	50° Be	6,000 tons

IV. MINING AND METALLURGICAL RESEARCH LABORATORY OF MITSUBISHI METAL MINING CO., LTD.

Introduction :—The Mitsubishi Metal Mining Co., Ltd., is one of the front ranking firm of its kind in Japan, a pioneer of the nation's basic industry, having a record of annual production of 4 tons of gold, 86 tons of silver, 20,000 tons of electrolytic copper 6,000 tons of electrolytic lead, 9,500 tons of electrolytic zinc and 2,300 tons of electrolytic tin.

Inaugurated in 1917, the laboratory gradually expanded its activities year after year, and in 1939 shifted to the present premises at Omiya city, Saitama Prefecture. The work is mostly connected with exploitation of mineral resources, mining, milling, smelting, refining, metal fabrication, fundamental study of chemical industry with metals as materials, technical improvement of mine and plant works and discovery of new process of mining operation.

Organisation :—The laboratory staff consists of 36 university graduates, 44 college graduates, 29 technical assistants, 35 non-technical assistants and 111 workers. The organisation of the laboratory is as hereunder : —

Director & Asst. Director
- —1st Research Section : Geology, Mining, Ore-dressing, Mine safety and Pollution.
- —2nd „ „ : Smelting & Refining.
- —3rd „ „ : Alloy, Metal Fabrication, Powder Metallurgy, etc.
- —4th „ „ : Physics, Chemistry, Assay Research Survey, etc.
- —Engineering Division.
- —General Affairs Division.
- —Accounting Division.

The up-to-date equipment for basic investigations include :—Quartz Spectrograph (for qualitative and semi-qualitative analysis of ores and metals), Polarograph (for analysis of elements), Raman spectrum photograph, Neo-photo, Pan-photo, Measuring apparatus of internal reflection, X-ray spectrum photograph, X-ray diffraction apparatus, Electron diffraction apparatus, Electron microscope, etc. Electron microscope is very useful in the study of (1) fine structure of surfaces of metals and minerals, (2) mine dust, (3) clays, (4) pigments and (5) metal powders.

The laboratory has various pilot plants for putting the research results into practice. There is a good mineral collection numbering 4,500 specimens, mostly collected by the late Dr. T. Wada.

The technical literature consists of 3,500 Japanese books, 4,300 foreign books and 10,000 back numbers of journals. 140 journals and periodicals are subscribed.

Although primarily engaged in mining and metallurgical engineering practice as relevant to the problems connected to their own mines, smelters and refineries, this laboratory also gives technical guidance to others from time to time.

Research Projects :—The number of current research projects is too numerous to be listed. A few broad aspects of the studies carried out in certain fields are briefly outlined below :—

Geology & Mining :—Investigations of ore composition, formation, structure, etc, providing fundamental data for working out methods of separating minerals; microscopical study of ores and mill products; geophysical prospecting; studies on rock drill and bit, and basic researches on methods of drilling and blasting.

Ore-Dressing :—The various mines of the company are provided with fundamental data on ore-dressing methods. Research results on various tailings have been very helpful in the recovery of minerals. Recent researches have made great contributions to the fundamental theory of flotation.

Mine Safety & Pollution :—Studies on preventive measures against mine pollution, effects of mine waters and other injurious elements on the growth of plants, silicosis, etc., are in progress.

Smelting & Refining :—The various smelters and refineries of the company, dealing with zinc, lead and tin, have been greatly benefited by the results achieved by laboratory investigations. Recent methods of treating electrolysis slime of zinc, tin, copper, lead etc., evolved as results of laboratory work, have been successful towards the recovery of cadmium, antimony, bismuth, gold, silver, etc.

Investigation regarding a suitable smelting method for cobalt bearing pyrites at Shimokawa mine, Hokkaido, is under progress. Other researches include basic investigations on roasting zinc ores from the company's mines and germanium recovery from ores containing germanium from the company's mine at Obira.

Metal Fabrication & Powder Metallurgy :—Researches on materials for bits, holder and rod of rock-drills are being pursued. Studies of tungsten carbide rock-drill bits have been helpful in the manufacture of some commercial products at the company's plant at Niigota. Studies on non-ferrous alloys are in progress.

Chemical Industry :—Research on sulphuric acid manufacture from expelled SO_2 gas at Hosokura zinc refinery has actually materialised. The manufacture of anhydrous chromic acid from ferro-chrome or chromite and some high-grade pigments has been commercially successful.

Coal :—The studies on coal include determination of quality of coal, coal dressing and utilisation of low-grade coal.

V. RESOURCES RESEARCH INSTITUTE

Established in 1952, as a result of amalgamation of the Fuel Research Institute and the Mining Technical Research Institute, the Resources Research Institute in

Tokyo is mainly connected with problems as relevant to conservation, development and utilisation of the mineral resources of Japan. The Institute employs 392 persons. There is a head office in Kawaguchi, a Liaison office at Tokyo Annex, and another office at Ukima Annex. In addition, there are Branch Stations of this Institute at Kyushu and Hokkaido. The Fuel Engineers' Training School is located at Ukima Annex, Tokyo. The present organisation of the Institute is charted below :—

Director—	—First Division	Researches on coal, lignite and coke
	—Second Division	Researches on metallic and non-metallic mineral products
	—Third Division	Researches on petroleum, other liquid fuels and tar
	—Fourth Division	Researches on combustion and heat economy
	—Fifth Division	Researches on coal preparation
	—Sixth Division	Researches on mining engineering and test and inspection of mining appliances
	—Fuel Engineers' Training School	
	—Analysis Section	(1) Researches on analytical and testing method and apparatus and their improvement (2) Analyses and tests of fuels on request from the public.
	—Planning Section	(1) Planning and co-ordination of research (2) Patent, standardization and information (3) Library
	—General Affairs Section	
	—Hokkaido Branch	(1) Research on mine safety (2) Test and inspection of mining appliances
	– Kyushu Branch	
	—Technical Adviser	

The Institute also issues certificates of analyses and test results of samples, on request from private enterprisers. Technical guidance is also rendered to the public from time to time. The Institute is further charged with the object of preparing various technical standards, e. g., the standard method of analysis of coal, coke and gaseous fuel, the standard method of analysis of minerals, the standard of the mining appliances and the specification of petroleum products. The Institute maintains close liaison with industry and the public, and publishes several reports and bulletins written in Japanese, generally with English abstracts.

VI. GEOLOGICAL SURVEY OF JAPAN

Introduction :—The Geological Survey of Japan was formally established in 1882. A Geological Section, within the set up of the Geographical Bureau, however, existed from 1878. In 1923 the Geological Survey building, together with the library and museum, was burnt during the Great Kwanto earthquake. The Survey was attached to the Ministry of Munitions during World War II, when sheet-mapping was discontinued. Most of the staff were then sent to Eastern Asia, and the remaining members were engaged in surveying undeveloped mineral areas consequent upon the necessity for war purposes. The museum and library, gradually built up since the Kwanto earthquake, were devastated by air raids in 1945. In 1946 the Survey shifted its headquarters to the present premises at Hisamoto-cho, Kawasaki-shi, Kanagawa Prefecture. There is a small city office at Kawada-cho, Shinjuki-ko, Tokyo. In addition, there is the Hokkaido branch office at Sapporo, and small circle offices at Sendai, Nagoya, Osaka, Hiroshima, Shikoku and Fukuoku.

In recent years the Survey's attention has been diverted to sheet mapping and long term systematic mineral investigations. The recent advances made include compilation of geological maps on the scale of 1 : 500,000, on the basis of new data. Published sheet maps, on the scale of 1 : 75,000 cover about one fourth of entire Japan, excluding Hokkaido. Since 1950 mapping is in progress on the scale of 1 : 50,000.

Organisation :—The present set up of the Geological Survey of Japan, with a technical staff of 270, under a Director, is given in the following chart :—

- Director
  - Geological Department ... .
    - 1st Sheet Mapping Section
    - IInd Sheet Mapping Section
    - Compilation Section
    - Engineering Geology Section
  - Mineral Deposits Departmet ...
    - Metal Section
    - Non-metal Section
    - Ore Reseach Section
  - Fuel Department ...
    - Coal Section
    - Oil & Gas Section
  - Geophysical Department ...
    - Exploration Section
    - Research Section
  - Technological Department ...
    - Topography Section
    - Boring Section
    - Chemistry Section
    - Workshop Section
  - Information Office
  - Publication & Library Section
  - Planning Section
  - General Affairs Section

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- Director
  - —Hokkaido Branch ...
    - —Sheet Mapping Section
    - —Mineral Deposits Section
    - —Fuel Section
    - —Technological Section
    - —General Affairs Section
  - —Sendai Residence
  - —Nagoya Residence
  - —Osaka Residence
  - —Hiroshima Residence
  - —Shikoku Residence
  - —Fukuoka Residence

Geological Department :—There are altogether 43 officers in this Department. The 1st Sheet Mapping Section is concerned mostly with mapping connected to stratigraphy, whereas the 2nd Sheet mapping Section generally maps out the areas with special reference to petrology. Sheet mapping on the scale of 1 : 75,000 was commenced in 1947, and before 1952, 95 sheets were mapped, out of which 78 sheets are published. Mapping on the scale of 1 : 50,000 began in 1950, and it is proposed to adopt this scale in Hokkaido region also. In 1950 it was planned to publish the geological maps of Japan on the scale of 1 : 500,000, in 14 sheets. and already three sheets are published. Surveys for geothermal energy and hot springs are also undertaken by this Department.

The Engineering Geology Section is concerned with the geological investigations of the dam-sites to ascertain the suitability of the sites in connection with power projects or construction of reservoirs for irrigation. This Section also examines the raw materials needed in civil engineering constructions. Other studies relate to hydrological surveys for industrial requirements, mutual interference of wells, ground subsidence as a result of excessive drawing of water, soil and rock weathering with reference to problems of landslides, etc.

Mineral Deposits Department :—Manned by 31 officers, this Department conducts surveys for metallic deposits (Metal Section), emphasis being laid on the regional investigations of important mineralised provinces. The Non-Metal Section mostly searches for minerals needed in ceramic industry. The Ore Research Section makes laboratory studies of ore components and their structures. This Department also undertakes identification work on minerals and rocks from private sectors and edits "Mineral Resources of Japan" in the form of several brochures for publication.

Fuel Department :—There are 28 officers here. The Coal Section carries out geological mapping of major coalfields and undeveloped coalfields, with particular reference to qualities and reserves of various coal seams, in co-operation with the Coal Bureau. Surveys for private enterprisers are also undertaken. The Oil and Gas Section investigates the possibility of locating new oil and gas fields and revises the work in proved oilfields, with emphasis on stratigraphical and structural geology, geochemical prospecting, boring and electric coring. In addition, studies in connection with submarine geology are made to gain knowledge on oil geology.

Geophysical Department :—The staff consists of 39 officers. Seismic, gravimetric, electric and magnetic methods of prospecting are undertaken to unravel subsurface geological structures and to locate mineral deposits. The largest reflection seismograph from the U. S. A. is being used in the survey of coal and oilfields to study the technique and mechanism of the reflection method. The geological structures of the oil and gas fields are being investigated by a new gravimeter imported from the U. S. A. Recent studies with the application of the gravimeter on the variations of gravity with respect to time resulting from earthquakes and volcanisms were very successful. Electrical prospecting is carried out for location of new ore deposits and aquifers. Magnetic prospecting is conducted for discovery of ore deposits. Laboratory studies of the magnetic susceptibility and residual magnetism of rocks are also being carried out. Radioactive prospecting by imported Beckman's Geiger counter in connection with survey of oil fields, gas fields and hot springs is also undertaken.

Technical Department :—There are 70 officers here. The Topography Section prepares large scale maps by triangulation, plane tabling and photographic surveys, for detailed geological mapping and geophysical surveys. The Boring Section undertakes borings to prove mineral deposits and aquifers on the completion of geological investigations. In addition to a high-speed diamond rotary drill imported in 1950, there are several rotary drills, percussion drills and hand drills. The Chemistry Section anaylses rocks, minerals, ores, ceramic materials, coal, petroleum, natural gas and mineral springs. About 500 full analyses and 3,000 partial analyses are performed every year. There is a Workshop Section attached to this Deparment which also prepares thin sections of rocks and minerals.

Branch Offices :—At Hokkaido Branch there are 30 officers, but in the small circle offices there are only a few officers in each locality.

Publications :—The important publications of the Geological Survey of Japan include Topographical Maps (mostly Japanese and English), Geological Maps (Japanese or Japanese and English), Mineral Maps (Japanese and English), Geological and Topographical Maps of the Oilfields and Coalfields (Japanese or Japanese and English) Memoirs (English), Bulletins (Japanese with or without English abstracts), Reports (Japanese mostly; special publications in English), Mineral Survey Reports (Japanese with or without English abstracts), Journals (Japanese), Reports on Geophysical Exploration (Japanese), etc.

The present publications comprise reports, maps, etc., amounting to over 100 every year. The important publications are listed below :—

(1) Geological sheet maps and explanatory texts, on the scale of 1 50,000 (Japanese and English).

(2) Geological sheet maps on the scale of 1 : 500,000 (Japanese).
(3) Monthly Bulletins (Japanese, with or without English abstracts).
(4) Reports (published non-periodically, in Japanese with English abstracts or in English).

Library :—60,000 copies of books and maps were burnt in the great fire of the Kwanto earthquake. 80,000 copies collected since then were also destroyed during World War II. The present library consists of 4,200 books and 28,000 copies of related literature. The Survey nowadays exchange its publications with 500 institutions in Japan and 154 institutions in foreign countries.

Museum :—The present collection of the museum comprises 5,000 minerals, 2,500 fossils and 1,000 rocks. A large collection of specimens was destroyed in the fires of the Great Kwanto earthquake and during World War II.

VII. GEOLOGICAL & MINING INSTITUTIONS OF TOKYO UNIVERSITY

Introduction :—With the termination of World War II. the educational system in Japan was totally changed, and the University organisations were reorganised. Undergraduate students of the Universities are at present required to attend classes for four years, the first two years in the Junior Course of the College of General Education, and the last two years in the Senior Course of any Faculty. The academic year begins on 1st April and ends on 31st March of the following year. On completion of the courses and successful passing of the required examination, students may graduate and receive graduation certificates (title of **Gakushi**) of the University.

After graduation (**Gakushi**), two years are necessary for the Master's degree (**Shushi**), which is obtained by thesis and examination. Doctorate degree (**Hakushi**) can be secured three years after the Master's degree by dissertation and examination. In Japan teaching of geology is done in 10 important universities, and mining is taught in 15 colleges and universities.

University of Tokyo :—In the University of Tokyo, Mining (including Petroleum Mining) and Metallurgy Departments are in the Faculty of Engineering, and the Departments of Geology (Geological Institute) and Mineralogy (Mineralogical Institute) are in the Faculty of Science.

In the Department of Mining there are five Professors in-charge of Petroleum Geology, Mining Geology, Mining Machinery, Applied Geophysics and Ore-dressing. In addition, there is an Assistant Professor in-charge of Mining Geology and a Lecturer in-charge of Petroleum Geology.

Judging from the syllabus and the laboratory equipment, it is obvious that a high standard of instruction is imparted to the Mining Engineering students. All students obtain practical training in a mine, mill or oilfield during the vacation. There are adequate laboratory facilities for work in mineralogy, geology, ore deposits, mining, mineral dressing, oil technology and geophysical prospecting. The Department of Mining has a large collection of scientific and technical books of Japanese and foreign origin.

A few years after graduation in mining, students aspire to get certificates of mine safety by examination conducted by the State. The certificates enable them to hold independent charge of a mine. Two kinds of certificates, namely, higher and lower standards, are issued ; the former would be required for holding independent charge of a mine, and the latter for foremanship. A graduate apprentice gets about 10,000 Yens monthly, and a Mines Manager 50,000-100,000 Yens monthly, in addition to bonus.

The geological education in Tokyo University is imparted by the College of General Education (preliminary standard), the Geological Institute and the Mineralogical Institute. Considering the syllabus, all round laboratory facilities and the strength of the staff in Geological and Mineralogical Institutes, the standard of geological education and research seems to be of a high order.

Most of the Professors speak and write English, and are familiar with the latest methods of researches in foreign countries. The laboratories are fully equipped with up-to-date and modern apparatus.

VIII. MINERAL RESOURCES OF JAPAN

Principal rock types :—The following is a broad classification of the principal rocks in Japan :—

(1) Diverse schists and gneisses of unknown age.

(2) Palaeozoic sandstone, slate, limestone and chert with intercalated volcanic rocks of basic composition.

(3) Mesozoic sedimentary rocks of marine and non-marine origin.

(4) Granitic rocks and basic intrusives, mostly of mesozoic age.

(5) Cenozoic sediments, partly tuffaceous, of marine and non marine origin.

(6) Volcanic rocks and hypabyssal intrusives (Cenozoic age).

Mineral Resources :—The geology of Japan is very varied and complex, and thus a large variety of minerals occurs in the country. However, Japan is not self-sufficient with regard to its mineral supplies, and is a large importer of minerals and mineral products.

Japan's production of iron and steel and aluminium is largely dependent on imports of raw materials. Sulphuric acid is manufactured in large quantity from pyrite.

It is also manufactured as a by-product of smelting of copper, lead and zinc ores. Japan imports about 1,000,000 tons of salt every year, the annual production in the country being roughly 450,000 tons in recent years. The non-ferrous metals produced include gold, silver, copper, lead, zinc, tin, mercury and antimony. Other by-products in refineries comprise bismuth, cadmium, palladium. platinum, selenium, tellurium, arsenious acid, copper sulphate, nickel sulphate, zinc sulphate, and zinc oxide. There are large resources of coal and lignite in Japan, but the country produces barely 10% of her requirements of petroleum.

The following Table sums up the up-to-date position regarding the relation of demand and supplies of metals and ores and minerals in Japan :—

(1) **Adequate domestic supply :**

(a) Metals or ores : Arsenic ; Bismuth ; Cadmium ; Copper ; Pyrite ; Silver ; Zinc.

(b) Non-metallic minerals : Abrasives ; Asbestos ; Bentonite ; Silica-brick stone ; Diatom earth ; Dolomite ; Dunite and serpentine ; Feldspar ; Fire-clay, low-grade Gypsum for Plaster of Paris ; Limestone ; Pottery stone ; Pyrophyllite ; Silica sand ; Sericite ; Sulphur.

(2) **Partial dependence on imports :**

(a) Metals or ores : Antimony ore ; Chromite ore ; Iron ore ; Lead and lead ore ; Mercury ore ; Molybdenum ore ; Tin ; Titanium ore.

(b) Non-metallic minerals : Asbestos (high-grade) ; Barite ; Fire-clay (high-grade) ; Fluorite ; Graphite (flaky) ; Gypsum for cement ; Kaolin.

(3) **Complete dependence on imports :**

(a) Metals or ores : Aluminium ore ; Cobalt ; Magnesium ; Manganese ore ; Nickel ore and matte ; Platinum ; Tungsten ore ; Vanadium.

(b) Non-metallic minerals : Bauxite for refractories ; Graphite (earthy) ; Magnesite ; Mica ; Phosphate ; Potash ore.

Statistical Data :—I collected some statistical data regarding mineral production, etc., during my visit to the Geological Survey of Japan. The data regarding the annual production of metallic minerals, non-metallic minerals, non-ferrous metals, by-products in refineries, aluminium metal, iron and steel, coal and petroleum and sulphuric acid of Japan, between the years 1950 and 1953, are tabulated below :—

Annual production of ores of Metallic Minerals of Japan

	1950		1951		1952		1953	
	Quantity (Tons	Grade (gm/ton)	Quantity (Tons)	Grade (gm/ton)	Quantity (Tons)	Grade (gm/ton	Quantity (Tons)	Grade (Gm/ton)
Gold ore								
Original ore	484,515	7.9	781,046	6.7	868,886	6.9	880,436	7.5
*	2,782 277	0.3	3,096,715	0.3	3,905,049	0 3	4,225,549	0.3
Total	3,266,792		3,877,761		4,773,935		5,105,985	
Silver ore		(gm/ton)		(gm/ton)		(gm/ton)		(gm/ton)
(a)	462,330	136.0	719,522	111.0	791,406	93.0	827,598	108.0
*	3,202,903	26.0	3,621,831	25.0	4,624,919	28.0	5.244,280	27.0
Total	3,665,233		4 341,353		5,416,325		6,071 878	
Copper ore		(Cu%)		(Cu%)		(Cu%)		(Cu%)
Original ore	2,904,370	1.4	3,184,430	1.3	3.954.466	1.4	4.504,074	1.3
*	276,256	0.5	447 556	0.5	634,868	0.4	589,972	0.3
Total	3,171,626		3,631,986		4,589,334		5,094,046	
Lead ore …		(Pb %)		(Pb %)		(Pb %)		(Pb%)
Original ore							1,188	9.9
(b) …	1,040,939	1 1	1,265,827	1 2	1,491,563	1.0	1,648,309	1.2
*	322,327	0.4	266,387	0.4	721,685	0.6	692,940	0.5
Total	1,363,266		1,532,214		2,213,248		2 342,437	
Zinc ore		(Zn%)		(Zn %)		(Zn %)		(Zn %)
Original ore	1,048,932	5.3	1,507,435	4 7	1 556,028	5.5	1,726 778	5.2
*	314,864	1.6	363,557	1.9	1 072 510	2 1	1,167,576	2.3
Total	1,363,796		1,870,992		2,628,538		2,894,354	
Iron sulphide ore		(S%)		(S %)		(S %)		(S %)
Original ore	834,744	42 1	1,653,427	38.3	1,782,481	37.0	1,043,757	38.4
(c) …					2,263,665	11.9	1,372,019	13.9
(d)	2,043,285	14.2	3,278,405	10.8	1,959,555	10.0	3,423,738	9.3
(e)	1,025,736	34.5	429,613	34.2	495,778	33.6	827,877	34.6
Total	3,093,765		5,361,445		6,501,479		6,667,391	

*By-product from other ores. (a) Production from gold-silver ore. (b) Production from lead-zinc ore. (c) Production from cupriferous pyrite ore. (d) Sulphur to be extracted from copper and zinc concentrates. (e) Sulphur ore (from pyrite-sulphur mines) to be used as material for sulphuric acid.

	1950		1951		1952		1953	
	Quantity (Tons)	Grade (Sn%)	Quantity (Tons)	Grade (Sn%)	Quantity (Tons)	Grade (Sn%)	Quantity (Tons)	Grade (Sn %)
Tin ore								
Original ore	17,393	0.7	48,613	0.8	81,212	0.8	64,837	0.9
*	219,750	0.3	411,947	0.2	524.904	0.2	539,699	0.2
Total	237,143		460,560		606,166		604,536	
Antimony ore		(Sb %)		(Sb %)		(Sb %)		(Sb %)
Original ore	435	9.8	2,054	7.7	1.053	9.8	2,074	9.9
*	41,185	0.5	41,472	0.5	44,855	0 5	47 825	0.4
Total	41,620		43,526		45,908		49,899	
Mercury ore		(Hg %)		(Hg %)		(Hg %)		(Hg %)
Total	18,629	0.3	27,794	0.4	26,536	0.4	34,405	0.4
Arsenic ore		(As %)		(As %)		(As %)		(As %)
Original ore	6,338	9.6	4,705	13.2	4,179	10.6	4,320	10.1
*	29,488	5 0	229,971	0.5	264,273	0.6	244,559	0.5
Total	35,826		234,676		268.452		248,879	
Iron ore		(Fe %)		(Fe %)		(Fe %)		(Fe %)
Total	1,088,908	43 0	1,275,841	40.0	1,472,179	39.0	1,548,948	41 0
Iron-sand ore	1,126,967	44.0	480,708	34.0	731.742	29.0	1,327,587	28.0
Manganese ore								
Manganese dioxide	10,645	61 0(MnO_2%)	12,162	63 0(MnO_2%)	11,148	59.0(MnO_2%)	14,153	60.0(MnO_2%)
Metallurgical manganese	190,159	30 0 Mn %)	291,380	27.0(Mn%)	317 811	28.0(Mn%)	321,044	26.0(Mn%)
Total	200,804		303,542		3 28,959		335,197	
Chromite ore		(Cr_2O_3%)		(Cr_2O_3%)		(Cr_2O_3%)		(Cr_2O_3%)
For refractories	30,843	26.0	41,174	27.0	46,115	28.0	34,965	30.0
For Metals	30 332	11.0	32,898	11.0	38,454	11.0	24,769	13.0
Tungsten ore		(WO_3 %)		(WO_3 %)		(WO_3%)		(WO_3 %)
Total	1,323	1.1	28,834	0.5	79,717	0.53	121,098	0.5
Molybdenum ore		(MoS_2%)		(MoS_2%)		(MoS_2%)		(MoS_2%)
Total	2,310	1.2	6,271	1.9	17,218	1.2	37.460	0.9
Titanium ore		(TiO_2%)		(TiO_2%)		(TiO_2 %)		(TiO_2%)
Total	—	—	—	—	9,686	17.0	6,370	22,0

* By-product from other ores.

Annual Production of Non-metallic Minerals in Japan

	1950 (Tons)	1951 (Tons)	1952 (Tons)	1953 (Tons)
Sulphur, crude ore	1,057,632	783,336	975,076	957,760
Sulphur, refined product	92,623	142,430	179,486	189,549
Flourite (concentrates)	2,425	3,995	3,952	6,537
Alunite (concentrates)	3,400	3,892	2,614	4,281
Barite (concentrates)	14,239	16,706	16,722	17,554
Graphite (concentrates)				
Flaky	2,595	2,262	2,344	2,632
Earthy	1,415	2,601	2,306	1,439
Gypsum (concentrates)	114,675	201,442	200,442	271,101
Chrysotile asbestos (concentrates)	4,613	5,351	3,041	4,078
Talc (concentrates)	12,401	12,198	10,568	14,426
Silica stone (concentrates)				
For cement	325,609	555,799	594,532	687,715
For general use	46,675	91,187	114,679	113,041
For fire-brick	157,202	249,720	177,289	107,654
Total	529,486	896,706	886,599	908,110
Silica sand (concentrates)				
For industrial use	359,704	507,788	494,011	552,597
For other uses	15,181	20,004	22,989	19,619
Total	374,885	527,792	517,000	572,216
Artificial silica sand (concentrates)	110,502	121,986	144,127	110,279
Feldspar (concentrates)	13.301	25,766	24,194	25,078
Substituting feldspar (concentrates)				
Aplite	12,110	17,539	17,124	20,153
Weathered granite	108,066	56,118	54,291	52,253
Total	120,176	73,657	71,415	72,406
Pottery Stone (concentrates)	45,442	73,414	67,172	51,630
Kaolin (concentrates)	10,481	14,746	12,907	15 148
Diaspore (concentrates)	1,989	5,280	9,003	6,172
Pyrophyllite (concentrates)				
For ceramic use	273,228	394,386	307,818	314,150
For fillers, carriers, etc.	76,928	100,061	105,066	176,226
Fire-clay (concentrates)	384,056	641,353	538,555	485,726
China-clay (concentrates)	35,422	48,049	35,808	35,853
Dolomite (concentrates)	511,719	652,785	667,102	723,141
Limestone (concentrates)	10,864,559	15,195,337	15,572,308	18,288 450

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*The annual production of other industrial minerals and rocks, i.e. dunite (refractories), Serpentine (fertilizer), sericite (fillers & carriers), bentonite, Fuller's earth, diatomaceous earth, abrasives & building stones are excluded.

Annual Production of Non-ferrous Metals of Japan

	(Unit)	1950	1951	1952	1953
Electrolytic gold	(g)	4,562,226	5,322,685	5,629,737	8,030,159
Electrolytic silver	(g)	135.048,720	157,933,257	178,660,332	249,222,292
Electrolytic copper	(kg)	84,749,143	90,948,870	94,401,629	91,054,528
Lead, electrolytic and Parkes lead	(kg)	16,588,616	17,885 029	19,375,303	23,146,612
Zinc, electrolytic and distilled zinc	(kg)	49,009,263	56 346,964	70,028,410	79,161,915
Electrolytic tin	(kg)	395,311	583,970	700,421	857,550
Mercury	(kg)	45,218	63,674	106,286	220,820
Antimony	(kg)	743,996	802,828	522,885	1,187 034

Annual Production of By-products in Refineries of Japan

	(Unit)	1950	1951	1952	1953
Bismuth	(kg)	33 049	42 010	43,576	49,968
Cadmium	(kg)	90,348	117,687	166,298	208,119
Palladium	(g)	1,826	709	2,645	2,197
Platinum	(g)	4,692	7,608	15,050	30,703
Selenium	(kg)	16,604	19,957	26,623	29 743
Tellurium	(kg)	—	—	—	150
Arsenious acid	(kg)	1,326,906	1,373,933	?	1,430,212
Copper sulphate	(kg)	3,979,926	7.487,025	8,079,798	8,277,175
Nickel sulphate	(kg)	1,113,956	729,760	1 189,772	?
Zinc sulphate	(kg)	8,117,610	11,314,812	6,412,421	11,389,127
Zinc oxide	(kg)	725,455	2,253,800	4,533,440	5,150,105

Annual Production of Aluminium Metal of Japan

	1950 (Tons)	1951 (Tons)	1952 (Tons)	1953 (Tons)
Aluminium (ingot, refined)	24,764	36,906	42,660	45,491
Alumina	48,309	78,432	86,971	91,306

Annual Production of Iron and Steel of Japan

	1950 (Tons)	1951 (Tons)	1952 (Tons)	1953 (Tons)
Pig-iron	2,232,911	3,126,918	3,474,204	4,518,140
Ferro-alloy	65,931	100,443	111,116	135,164
Steel	4,838,522	6,501,849	6,988,359	7,662,161

Annual Production of Coal and Petroleum of Japan

	(Unit)	1950	1951	1952	1953
Coal, total	(Ton)	39,312,390	43,311,901	43,358,985	46,530,638
Lignite	(Ton)	1,204,856	1,403,039	1,539,441	1,485,788
Petroleum (crude)	(Kl*)	325,539,	366,732	339,212	334,074
Natural gas	(cmΦ)	69,137,739	82,821,325	91,090,528	110,481,694

Annual Production of Sulphuric Acid of Japan

	1950 (kg)	1951 (kg)	1952 (kg)	1953 (kg)
50% acid	261,157,093	310,216,501	223,781,079	?
98% acid	251,485,431	346,020,338	322,272,380	?

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*Kilolitre.

ΦCubic metre.

IX BORING MACHINES

Introduction :—There are several firms manufacturing boring machines in Japan. I visited two factories near Tokyo, namely, Tone Boring Co., Shimomegure, and Koken Boring Machine Co., Ltd., Megure-ku.

The Tone Boring Co., with experience of 30 years, maintains trained engineers and mechanics, and is accepted as a leading firm manufacturing boring machines and drilling equipment in Japan. Their boring machines have been thoroughly tested in various spheres of geological prospecting for coal, metallic and non-metallic minerals, drilling grouting holes, testing sub-surface foundations, etc. The Koken Boring Machine Co. claims to have 20 years of experience in the production of machines, but is not considered so important like the other firm. I had an opportunity to see some of the models at work, and I was satisfied at their performance.

I have collected details of various types of boring machines manufactured by both firms. They are prepared to accept orders for boring machines and can deliver the goods one month after the order. They are willing to send their Boring Engineers to India for technical advice and assistance to run the machines. The firms are also willing to impart training to our men if they are sent to Japan. A period of three months would be needed to train our operators.

Tone Boring Machines :—The specifications and prices of three models of diamond boring machines, which may be of interest to us, are given below :

(1)

Model	RL-800
Dimensions (m)	1.8×1.3×1.3 (Height, Width, Breadth)
Weight (kg)	1,200
Drilling capacity (m)	800—1,300
Direction of drill	Vertical, horizontal and inclined
Power	15—30 H.P. (Electric motor or oil engine. Including power for driving pump)
Maximum hole diam.	100 mm.
Minimum hole diam.	37 mm.

Price (complete with accessories and spare parts ex-godown) .. 15 million Yens.

(2)

Model	RL—500
Dimensions (m)	1.6 x 1.3 x 1 3 (Height, Width, Breadth)
Weight (kg)	1,100
Drilling capacity (m)	500—700

Direction of drill	Vertical, horizontal and inclined
Power	10–20 H. P. (Electric motor or oil engine. Including Power for driving pump)
Maximum hole diam.	150 mm.
Minimum hole diam.	46 mm.

Price (complete with accessories & spare parts, ex-godown) ... 10-11 million Yens.

(3)

Model	RL–50
Dimensions (m)	0.8 x 0.7 x 0.7 (Height, Width, Breadth)
Weight (kg)	180
Drilling capacity (m)	50–100
Direction of drill	Vertical, horizontal and inclined
Power	3.5H.P. (Electric motor or oil engine. Including power for driving pump)
Maximum hole diam.	65 mm.
Minimum hole diam	37 mm.

Price (complete with accessories & spare parts, ex-godown) .. 1.2 million Yens.

Koken Boring Machines :—The specifications and prices of three types of diamond boring machines, which may be suitable for our requirements, are given below :—

(1)

Model	ME—4
Capacity	300 meter (1,000 feet)
Feed	Hydraulic feed
Drill rod diam.	33.5 mm (1-5/16") or 40 mm (1-9/16")
Maximum hole diam.	150 mm (6")
Bit r.p.m.	200-400-600-800 r.p.m.
Power	Either electric motor or diesel engine (10 H.P.)
Weight (less power unit)	900 kgs. (2000 lbs.) Consists of four compact component parts—the hoist, electric motor, swivel head and frame
General dimensions	Height 1350 mm (4'-5') Length 1800 mm (6'-0') Width 800 mm (2'-7")
Angle range	360°
Bit type	Diamond, Alloy bit and Chilled steel shot

Price (complete with accessories and spare parts, **f.o b**. Yokohama) .... 1,958,542 Yens

Say 2 million Yens.

(2)

Model	OE
Capacity	200 metre (600 feet)
Feed	Hydraulic feed
Drilling rod diam.	33.5mm (1-5/16′) or 40mm (1-9/16′)
Maximum hole diam.	100mm (4″)
Bit r. p. m.	150-300 600-1000 r. p.m.
Power	Either electric motor or diesel engine (7.5 H.P)
Weight (less power unit)	530 kgs. (1160 lbs.) Consists of four compact parts—the hoist, electric motor, swivel head and frame.
General dimensions	Height 1185 mm (3′-11″) Length 1380 mm (4′-6″) Width 650 mm (2′-2″)
Angle range	360°
Bit type	Diamond, Alloy bit and Chilled Steel shot

Price (complete with accessories and spare parts, **f. o. b.** Yokohama)....................1,621,942 Yens.

(3)

Model	PE—2
Capacity	100 metre (300 feet)
Feed	Hydraulic feed
Drill rod diam.	33.5 mm (1-5/16″)
Maximum hole diam.	100 mm (4″)
Bit r.p.m.	220-380-750 r.p.m.
Power	Either electric motor (5 H.P.) or air motor (7.5 H. P.)
Weight (less power unit)	240 kgs. (530 lbs.) Consists of four compact component parts—the hoist—electric motor—swivel head and frame
General dimensions	Height 950mm (3′ - 1″) Length 1180mm (3′ - 10″) Width 700mm (2′ - 4″)
Angle range	360°
Bit type	Diamond, alloy bit and Chilled steel shot

Price (complete with accessories and spare parts, **f. o. b** Yokohama)......1,173,522 Yens.

X. NISHITAMA CEMENT FACTORY

Introduction :—The cement manufacture in/Japan started as a Government enterprise in 1871, and subsequently with the industrialisation of the country the industry led to the installation of various plants. The cement industry in recent years is overdeveloped and cement is produced in large quantities for foreign export.

The Nishitama cement factory, a branch organisation of the Nihon Cement Co. Ltd., was installed in 1928 as the first and complete Wet-process cement plant in Japan. Located about 50 kilometres from Tokyo, with a production of 34,000 tons per month, the plant employs 502 men excluding 73 office workers. The Nihon Cement Co. Ltd., having 10 plants in the country, produces a total of 270,000 tons of cement per month.

Raw Materials :—The limestone quarries comprising three Glory-hole opencasts are adjacent to the works, the maximum depth of the opencasts being 100 metres. Limestone belong to a series of highly folded Permo-Carboniferous rocks in a hilly terrain, with small intercalations of chert and quartzite. The material from the quarries is taken to the works by a belt conveyer. An average analysis of limestone is given below :-

		Per cent.
Loss	...	42 67
SiO_2	...	0.60
Al_2O_3	...	0.32
Fe_2O_3	...	0.14
CaO	...	55.00
MgO	...	0.42
	Total—	99.20

Clay is obtained from the neighbourhood. It is a shale of Miocene age. When it is poor in SiO_2, some quantity of chert or quartzite is added. Gypsum is partly imported from elsewhere.

Grinding & Preparation :- Limestone and clay are separately crushed in the mills. The raw materials, mixed with water, are ground in the raw mill. Some quantity of pyrite sinter (by-product in the manufacture of ammonium sulphate by using pyrite), a ferric oxide, is also added to the raw materials in the raw mill, for giving necessary Fe_2O_3 to the Portland cement.

The resulting slurry from the raw mill is stored in slurry tank agitated thoroughly by compressed air, analysed, and its chemical composition is corrected to insure uniformity of the quality. The slurry thereafter passes through slurry filter and becomes cakes.

Burning & Cooling :—Caked slurry passes through high temperature rotary kilns and is subsequently cooled by Air Quenching Cooler. The product comes out as clinker, a semi-product of cement. There are three kilns, each with a capacity of 400 tons per day. They are 65 metres long and have a diameter of 3.4 metres. The temperature in the kiln is 1,450°C. The Air Quenching Cooler, imported from Denmark, is said to give 10% saving in coal.

The cement dust from the rotary kiln goes into the waste-heat boiler, and thence to the electrical dust collector (Cottrel precipitator) for reclaiming cement dust.

Grinding & Packing :—About 4% by weight of gypsum is added to the clinker and ground in cement mill. Cement thus obtained is stored in silo and packed by Bates Packer for delivery.

Fuel :—High calorific value coal, from near Hokkaido, dried and pulverized, is blown into the kiln and burnt. About 260 kgs. of coal is required per ton of cement.

Power :—Waste heat from the kilns is utilised for generation of electric power by means of waste-heat boiler. This yields nearly 80% of the power needed in the plant, the rest being purchased from a power company.

Testing :—Raw materials and products are analysed from time to time at the laboratories to insure the production of high quality cement. An analysis of cement is given below :—

		Per cent.
SiO_2	...	22.19
Al_2O_3	....	5.08
Fe_2O_3	....	2.34
CaO	...	64.87
MgO	...	1 21
SO_3	...	1 73
Loss	...	1.03
Insoluble	...	0.36

XI. TSURUMI SHEET GLASS FACTORY

Introduction :—The Tsurumi sheet glass factory near Yokohama, employing about 1,500 staff and labour, is one of the three flat glass factories belonging to the Asahi Glass Co. Ltd., which was set up in 1907 as the first sheet glass manufacturing company in the Far East. The factories of the Asahi Glass Co. produce nearly 60% of the sheet glass manufactured in Japan. The company's Research Laboratory located near the Tsurumi factory is considered to be the best of its kind in Japan.

The Asahi Glass Co. offers all kinds of technical service and guidance in various branches of the flat glass industries in matters of design and purchase of equipment for erection of new plants. I am informed that the company is being consulted by the proposed sheet glass plant at Bhurkunda and the Sodepur Glass Works near Calcutta. The capital cost needed for installation of a modern sheet glass factory, designed to yield 90,000 cases of sheet glass per month, is stated to be 8 million dollars.

Products :—The products manufactured at the Tsurumi factory are thin sheet glass (photographic sheets), plain window and sheet glass, ground glass, figured glass, ribbed glass, wire glass and polished glass (plate, figured and wire). They have special structure and characteristics for particular requirements and are generally tailor-made to any specific demand. The maximum size of sheet glass is 6′ × 12′, the usual thickness being 3 – 6 mm (minimum) to 10 – 15 mm (maximum). The following products, also manufactured by the company, are of special interest :—

Tempered safety glass :—An ordinarily 'flat or curved glass adequately heated and rapidly cooled, have a toughness to resist breakage while loading. It is shock-proof and breaks without producing sharp edged splinters. Testing of strength is performed on each sheet before delivery to the market.

Laminated safety glass :—Made of two or more flat or curved glass sheets with one or more polyvinyl butyral interlayer films sandwitched in between them ; it is widely used for automobile, ship, aeroplane, etc., it prevents glass splinters from flying off in case of accident.

Pair glass :—This product consists of two or more glass sheets with one or several layers of dehydrated air enclosed by a metal spacer between them and has high thermal insulation and sound absorption properties.

Manufacturing Process :—The batch mixture for window glass is constituted of silica sand (70%), soda ash and saltpetre (14%), crushed limestone, dolomite and felspar and some quantity of arsenic acid. Generally the silica sand contains 98% $Si0_2$, 1.2% Al_20_3 and 0.06% Fe_20_3, and is obtained from weathered granite after washing or from silicified zone in andesite. The manufacturing process consists of the following stages of operation :—

(1) Charging of materials,

(2) Melting in tank furnace where the temperature ranges from 1,000°C to 1,500°C.

(3) Drawing machine—the melt is vertically drawn up from the furnace tank into sheet glass by the Fourcault process.

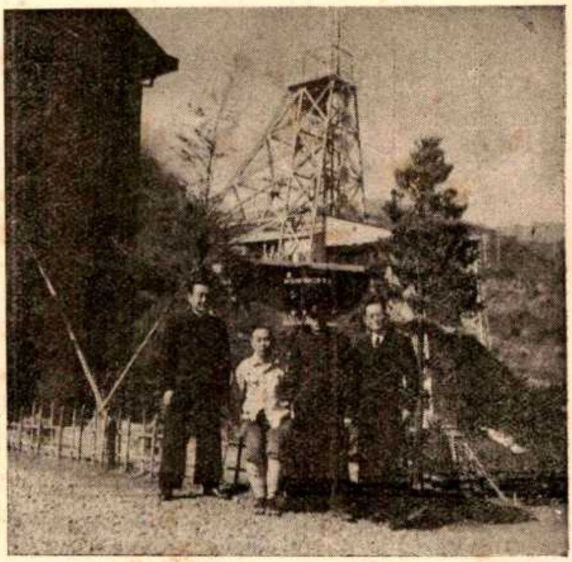
(4) Cutting off a large sheet from a ribbon of glass.

(5) Packing of glass sheets.

Another process involves rolling out of melt in the form of rolled glass, i.e., horizontally drawn glass, between rollers, for imprinting various designs (figured glass). Ribbed wire or figured wire glasses are also manufactured by this process.

Producer gas from coal, utilising about 3,000 tons of coal per month, is used for the furnace, which can also be fired by heavy oil. The factory needs 2 million Kilowatt-hour of electrical energy per month. For the manufacture of polished plate glass, the sheets are ground and polished. Grinding is done by sand and garnet, and polishing by chemically prepared iron-oxide, chemically manufactured gypsum being used for fixing glass sheets before grinding

Part of Kamioka Smelter and Sulphuric Acid Plant



No 11 Shaft Hitachi Mine

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Recent Trends in Mineral Development in the U. S. S. R. and Western Europe 1

By

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RECENT TRENDS IN MINERAL DEVELOPMENT IN THE U. S. S. R. AND WESTERN EUROPE*

BY
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I. INTRODUCTION

The United Nations, under the sponsorship of its Technical Assistance Administration (TAA) and the Economic Commission for Asia and the Far East (ECAFE), organized a Study Tour of a Group of 11 Geologists and Mining Engineers from Asia and the Far East in the U.S.S.R. and Western Europe. The Group assembled in New Delhi at the end of July, 1955, and reached Moscow via Kabul on the 4th August, 1955. The Group spent about two months in the Soviet Union and six weeks in England, France, West Germany and East Germany, visiting Geological Surveys and training centres for Geologists and Mining Engineers, and studying the modern techniques of exploration for coal and metallic and non-metallic mineral deposits. The itinerary of the Group was as hereunder :—

4th August	—21st September	...	U.S.S.R.
22nd September	—4th October	...	U.K.
5th October	—16th „	...	France.
17th „	—27th „	...	Federal Republic of Germany.
28th „	—4th November	....	German Democratic Republic.

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* Published with the kind permission of the Director, Geological Survey of India.
Read before the Society on 16. 7 56.

During this Study Tour the Group held discussions with the State officials and several top-ranking Geologists, Geophysicists, Mining Engineers, Metallurgists, etc., of the U.S.S.R. and Western Europe. As such, it has been possible to obtain a large amount of information and technical data in a comparatively short time. A preliminary report prepared jointly by the members of the Group was drawn up at Geneva at the conclusion of the tour. The final report which will include several diagrams, geological maps, geological sections, flow-sheets (beneficiation of coals and ores), etc., is being published by the ECAFE and will be of help to the ECAFE countries in the organisation of their Geological Surveys and mineral development.

It is hoped that these short notes, reflecting the recent trends in mineral development in the U.S.S.R. and Western Europe, prepared by the author who was a member of this Study Tour, will be of some help to the members of the Geological, Mining and Metallurgical Society of India.

II. GEOLOGICAL SURVEYS AND EXPLORATIONS FOR MINERALS.

U. S. S. R.

Early History of Geological Survey

In the U.S.S.R. until 1912 there were 15 to 20 Geologists working under the Geological Committee set up in 1882. The number increased in the following years between 50 and 80, and geological mapping was primarily undertaken in parts of the western region. A Geological Prospecting Trust (Sojuzgeorazvedka) was created after the 1917 Revolution, which was subsequently reorganized into a Prospecting Department, and eventually in 1938 a Committee on Geology under the Council of Ministers was established.

Ministry of Geology & Conservation of Mineral Resources

At the end of World War II, the Soviet Government felt the necessity to strengthen the geological service and set up a separate Ministry of Geology in 1946, the first Ministry of its kind to be set up in any country of the world. This was re-organized in 1953 as the Ministry of Geology and Conservation of Mineral Resources which is the highest body of the geological service in the Soviet Union. Among the chief functions of the Ministry are systematic geological mapping of the whole Union, searching and prospecting of known and new mineral deposits, determination of ore reserves, documentation of all geological data throughout the country, planning for the development of new deposits, controlling the rate of exploitation of minerals, minimizing mining losses, utilization of all mineral components of mixed ores, etc. The total strength of the Ministry is 20,000, out of which 14,000 are Geologists. The number of university graduates in geology is 8 000, and the number of junior geologists from Technicums is 6,000. The 1955 budget of the Ministry was of order of 3,700 million Roubles. The staff of the Ministry is entitled to the facilities of the rest house near Moscow and the sanatorium under construction in Sochi by Black Sea.

There are also several other Ministries in the U.S.S.R., e.g., Coal, Oil, Ferrous Metallurgy, Non-Ferrous Metallurgy, Chemical and Building Materials, etc., which employ Geologists with a view to carrying out detailed geological mapping of mineral deposits, prospecting and revision of ore reserves, hydro-geological studies, etc., as required for their specific purposes.

Regional & Territorial Geological Departments

The Soviet Union covers some 22 million kilometers comprising about one-sixth of the land surface of the globe, and therefore for efficient discharge of all geological work in the U.S.S.R. the Ministry of Geology & Conservation of Mineral Resources functions through the following four Main Regional Geological Survey Departments and 22 Territorial Geological Departments :-

(1) **Western Region Geological Department**—This comprises the Russian platform, Karelia, Ukraine and Caucasus, and includes seven Territorial Geological Departments.

(2) **Middle Asia and Kazakhstan Geological Department**—This covers Kazakhstan, Middle Asia, Uzbekistan and Turkmenistan, and includes six Territorial Geological Departments.

(3) **The Urals and Siberian Geological Department**—This covers the Western Siberian platform and the mountain region of West Siberia up to Lake Baikal and includes five Territorial Geological Departments.

(4) **Far Eastern Region Geological Department**—This covers Eastern Siberia and includes four Territorial Geological Departments.

The Urals Geological Department, visited by the author, a typical Territorial Geological Department of the main Geological Department of the Urals, covers an area of two million square kilometers of the Urals region and employs some 300 Geologists. The region is one of the most important mineral-bearing areas in the U.S.S.R. where about 15 Geological Expedition Parties are now operating. The Department has its own laboratories, museums, libraries and workshops, and its main function is to conduct detailed systematic geological mapping of the territory, co-ordinate all geological data, publish geological maps of different scales and undertake detailed prospecting of all mineral deposits excepting oil and gas. Geological maps of the Urals on a scale of 1:1,000,000 and 1:500,000 and 50 sheets of geological maps on a scale of 1.200 000 have been already completed, and geological mapping on a scale of 1:50,000 is in progress. A magnetic map of the Urals on a scale of 1:1,000,000 and hydro-geological map of the Urals have been also completed.

Special Organisations of the Ministry of Geology and Conservation of Mineral Resources.

The Ministry of Geology & Conservation of Mineral Resources has also several special organisations as follows :—

(1) **Geophysical Department**—Six Territorial Geophysical Trusts (Central, North-Western, Urals, Middle Asia, Siberian and Far Eastern) are responsible for undertaking geophysical surveys in the Soviet Union, in close collaboration with the Territorial Geological Department.

(2) **Department of Engineering Geology and Hydro-Geology** includes the following :—

(i) All-Union Hydro-Geological Trust surveys the ground water resources and maintains a series of Hydro-geological observatory stations and landslide recording stations.

(ii) All-Union Aero-Geological Trust conducts aerial surveying and geological mapping of the inadequately surveyed and inaccessible areas of Siberia and the Far East.

(3) **All-Union Geological "Fund" (Central Bureau)**—Its main function is to assemble all geological data from the entire country for correlation and compilation work. It further issues every year to all organizations a map indicating the status of geological surveys in different parts of the Union for reference work.

(4) **Scientific Research Institute**—Several research institutes, directly or indirectly connected to geological matters, work under the Ministry. The All-Union Scientific Research Institute in Geology in Leningrad, the Scientific Research Institute of Arctic Geology, the Institute of Hydro-Geology and the Caucasian Institute of Mineral Raw Materials are particularly mentionworthy.

(5) **Manufacturing Plants**—The Ministry maintains several plants for the manufacture of drilling and mining equipment, geophysical instruments, outfits, etc., which are supplied to the Territorial Geological Departments, Expedition Parties, etc., through the Main Department of Technical Supply.

(6) **Division of Training Institutions and its Technical Schools.**

Territorial Commissions & State Commission on Mineral Reserves

In the Soviet Union there are special bodies called the Territorial Commission on Mineral Reserves which are independent of the Territorial Departments. Their main function is to check over the reliability of the data on geological prospecting carried out by the Territorial Geological Department. In addition, there is a State Commission on Mineral Reserves working directly under the Council of Ministers. It checks up the estimates on reserves, judges the degree and reliability of the geological studies, determines the suitability of opening up of the deposits, opines on the utilization of all mineral components and guides the Territorial Commissions. In the U. S. S. R. no mineral deposits can be opened up unless the reserves are thoroughly checked and confirmed by the State Commission on Mineral Reserves.

SCALE OF GEOLOGICAL MAPPING

Geological mapping in the Soviet Union is done according to a definite plan, with an ever increasing detail. The geological map on a scale of 1:5,000,000 is being published and the geological map on a scale of 1:2,500,000 is under preparation. Work on the 1:1 000,000 scale geological map, involving 172 sheets, is under progress and is scheduled to be completed in 1960. The maps merely give a general idea of the regional stratigraphy and structure. Special tectonic, structural and palaeo-geographical maps are also being compiled. Geological maps on a scale of 1:500,000 of certain territories are also prepared, and the maps of the Urals and Caucasus on this scale will be published in 1957.

Detailed geological mapping follows in mineral-bearing areas on scales of 1:200,000, 1:100,000, 1:50,000 or 1:25,000. The scale of detailed geological mapping is mainly determined by the character of the deposit, the geological complexity of the area, and the nature of mineral components. Mapping on scales of 1:10,000 to 1:5,000 usually follows in case of detail prospecting of ore deposits. The 1:10,000 scale is generally employed in case of large sedimentary ore deposits or large deposits of igneous origin. Detailed mapping on scales of 1:5000 to 1:2,000 is required to delineate the ore-bodies and to study the structure of the ore zones, but mapping on a scale of 1:1,000 follows in case of structurally complicated ore deposits. Underground geological mapping of ore deposits is usually done on scales of 1:500, 1:200 and 1:100.

PROSPECTING FOR MINERALS.

With regard to geological survey and prospecting of mineral deposits, the Ministry of Geology & Conservation of Mineral Resources is guided by the five-year plans, on the basis of which annual work programme is chalked out. The Ministry further revises the mineral resources of the union every year.

The programme of mineral prospecting and exploration in the U. S. S. R. is universally kept ahead of the industrial development programme. As for instance, if any enhanced output of steel each year is contemplated, the additional quantity of various raw-materials necessary is determined in advance, and the proportionate increase in annual output of iron-ore, limestone, coal and manganese-ore from certain mines is fixed up for maintaining the production target. According to Soviet practice, a coal mine must have a reserve of 10 million tons to yield an annual output of 300,000 tons, 50 million tons to yield 900,000 tons a year and 80 million tons to yield 1.2 million tons a year.

In the Soviet Union, the prospecting methods include visual studies, geophysical surveying, geochemical investigations and engineering methods (drilling, trenching, cross-cuts, excavations, shaft sinking etc.), taken up singly or in combination, in all phases of exploratory work and mining development.

Geophysical explorations are very common in the U.S.S.R., and magnetic surveys based on the differences in magnetic qualities of rocks are undertaken for the prospecting of ore-bodies as well as for geological mapping. Some of the standard geophysical equipment may be mentioned. In seismic prospecting the usual units comprise seismic station (SS-26-51D), field seismic receiver (SP-16), seismic bore hole receiver (SIS-49), autoblasting truck, water transporting vehicle, drilling machine (AVB-3-100), drilling machine (UKB-2-100) and drilling machine (ZIV-150). Electrical prospecting equipments include field electric potentiometer (EP-1) and field electric prospecting station (ERS-23). The standard equipments for gravimetric prospecting consist of gravimeter (SN-3), gravimeter (GAK-3M) and gravimeter altimeter (GB-52). In magnetic prospecting the use of magnetic vertical scales (M-2) is common, and for coring work semi-automatic coring station (PKS-750) and automatic coring station (AKS-750) are employed.

Geochemical prospecting methods used in the U.S.S.R cover litho-chemical, bio-chemical, hydro-chemical, and atmo-chemical studies. The average density of metallometric sample in geological surveying for ore deposits on a scale of 1:200,000 or 1:100,000 is of the order of 10 samples per square kilometer, and the average density of samples in mapping on a scale of 1:50,000 to 1:25,000 is 20-40 per square kilometer.

The Ministry periodically issues instructions to the Expedition Parties and workers regarding prospecting methods, calculation of ore reserves, classification of reserves, sampling, geological data, etc. Great attention is paid to study the structure of the ore deposits and associated rocks.

In the day to day work of any mine, geological work is considered very important, and very often the Chief Geologist of a mine works as a Deputy Director of that enterprise. The individual mines have their own team of Geologists for large scale mapping, systematic sampling, assessment of reserves according to various categories and mineralogical and petrological studies. Prospecting operations do not cease with the opening up of a particular mine, as ore reserves are revised annually, detailed revisions being done every four months.

AERIAL SURVEYS & GEOLOGICAL WORK

In Russia aerial mapping is being increasingly used in the survey of natural resources,, and air-borne geophysical surveys have been successfully employed for geological mapping and discovery of mineral deposits. The Aero-Geological Trust of the Ministry of Geology & Conservation of Mineral Resources prepares photo aerial maps and carries out aero-geophysical surveys appertaining to the following works :—

(1) Survey and geological mapping of complicated regions
(2) Geophysical investigations
(3) Geo-morphological work
(4) Hydro-geological and geo-botanical studies
(5) Reservoir and dam-site problems
(6) Location of mineral deposits
(7) Survey of shallow water areas

Aerial photographs of an area are taken at least one year prior to the geological mapping work and relevant aerial photographs and topographical maps are made available to the field parties two months before commencing actual geological mapping. Judging from experience in the U.S.S.R. it would appear that in geological mapping on different scales, the scales of aerophoto surveys should vary as follows :—

(1) If the geological surveying is to be done on a scale of 1.1,000,000 or 1:500,000 aerophoto surveys should be on scales of 1:50,000 to 1:40,000.

(2) If the geological surveying is to be done on a scale of 1 200,000 or 1:100,000, aerophoto surveys should be on a scale of 1:25,000.

(3) In detailed geological mapping work, on a scale of 1:50,000 or larger, the scale of the aerophotographs should be twice that of the geological maps.

No special types of aeroplane for aerial survey are manufactured in the Soviet Union. For small scale aerial surveys, Soviet planes UL—12 (cruising speed ; 400 km per hour, maximum flight duration—8 hours) and PO—2 (cruising speed , 200 km per hour, maximum flight duration—8 hrs.) are generally used, whereas lighter planes are employed in case of large scale mapping. The camera used was invented by Professor Rusinikof, and recently a slit camera invented by Mr. Seminov has been introduced.

Categories of Reserves

In the Soviet Union the ore reserves are grouped under five categories as follows :—

A_1 category—	Highest category reserves evaluated from very detailed surveying and prospecting ; ready for winning.
A_2 category—	Very high category reserves evaluated from very detailed surveying and prospecting ; used for drawing up final development plans.
B category—	Reserves of basic type evaluated from geological surveying and prospecting (drilling) and for which dressing techniques have been developed ; used for general economic planning and preliminary development projects.

C_1 category— Low category reserves based on geological surveying and scattered drilling and ore sampling; used for preliminary economic planning and to establish targets for detailed investigation.

C_2 category— Very low category hypothetic reserves based on geological indications, and not confirmed by drilling and ore sampling; used for long-range preliminary planning.

Grouping of Mineral Deposits & Determination of categories of Reserves

Prospecting methods to be employed for mineral deposits naturally depend on the nature of the deposits, which in the Soviet Union are usually grouped as follows :—

Ist group of deposits—Simple in form, large in size, with uniform distribution of minerals e. g., deposits of iron-ore, coal, etc. A normal grid of bore holes is undertaken to determine the high category reserves in this group, and excavation is undertaken for controlling the data of bore hole samples and for bulk sampling.

2nd group of deposits—Large deposits of different or complicated forms with uneven mineral components. A normal grid of bore holes usually determines B category reserves, whereas close-spaced bore holes supplemented by excavations, etc., may prove A_2 category reserves.

3rd group of deposits—Medium size deposits with uneven distribution of minerals, e. g., vein or dyke type ore-bodies. Reserves of C_1 category are determined by bore holes, whereas A and B category reserves may be assessed by excavations, etc., after drilling.

4th group of deposits—Small size deposits of complicated forms with uneven distribution of minerals. C category reserves may be established by bore holes, and B category reserves by excavations and underground drilling.

5th group of deposits—Small pocket deposits. C category reserves are usually established, as A and B category reserves can not be easily determined by usual prospecting methods.

Geological Prospecting Expedition Parties

Several Geological expedition Parties belonging to various Territorial Departments work in many regions of the U. S. S. R. The workers of the Expedition Parties are provided with all modern amenities including hospital facilities, communications and supply, and a fleet of transport is also maintained. A brief reference to the organization and work of several such parties visited by the author is given below.

The organization of the Shing-Magian Geological Expedition Party was headed by a Director, and assisted by a Chief Engineer and a Chief Geologist. The Party had 18 Senior Geologists and 50 Junior Technicians, the other workers totalling about 1,000. About 5,000 meters of tunnelling and 6,000 meters of drilling were being completed annually. Mapping on a scale of 1:10,000 covering 150 square kilometers was done within five years. The party was in charge of prospecting for antimony-mercury deposit in a mountainous country where a large sum of money was spent for constructing roads, houses, laboratories, workshops and power stations, the annual expenditure incurred for the prospecting amounting to some 25 million Roubles each year. As a result of severe winter, work was ordinarily limited to five months every year and 3-4 months in extreme winter.

The recent discovery of a large iron-ore deposit in the Sarbai area, accredited to detailed geological and geophysical prospecting, is a typical example of determined efforts of the Soviet Union to discover the mineral resources of the country by systematic work. As a result of 10 years of work now it has been established that this area, where no outcrops of iron-ore are seen, holds one of the most important iron-ore deposits of the Union, where opencast mining is expected to commence very soon. The prospecting operations during the year of maximum activity cost some 9 million Roubles. Systematic aero-magnetometric survey on a scale of 1:100,000 from 1946 to 1949, in the Turgai area between the Urals and the Kazakh region, blanketed by Tertiary and post-Tertiary loose deposits, brought about the discovery of this iron-ore field. Subsequently followed surface magnetic surveying on a grid of 50 × 100 meters and a gravimetric surveying on a grid of 50 × 300 meters. This work was supplemented by drilling with more than 30 machines (ZEF-650, KAM-500, SBY & ZEF-150) which proved large magnetite deposits at a depth of 70 meters.

The Geological Prospecting Expedition Party of the Urals Territorial Geological Department and the Turgai Geophysical Expedition Party of the Urals Geophysical Trust were jointly responsible for the work in the Sarbai area which is almost complete. The work of the Geological Expedition Party is still continuing for geological mapping of "closed areas," checking up magnetic anomalies and hydro-geological studies (drilling for water, experimental pumping of water, study of sub-surface water levels, water analysis and soil studies). Hitherto, the geological work involved geological mapping, surveying petrographical and spectrographic analysis of rocks, ore sampling, mineral dressing, magnetic surveying and ground water studies. The Expedition Party maintains a geological division, a power division, repair service, drilling shop, construction department, garage services and an accommodation division. There are about 800 workers in the camp. The Party has a staff of 12 Geologists (including 6 Hydro-geologists), 1 Electro-mechanic Engineer, 1 Geophysicist, 1 Geophysical Assistant and 55 Technicians.

The Kremenchung Geological Prospecting Expedition Party is now investigating the Kremenchung iron-ore deposit, similar to the well known Pre-Cambrian Krivoy Rog iron ore deposit. The Party consists of two departments, namely, geological department and productive department. The geological department comprises the field section (examination of cores, preparation of geological sections, planning of prospecting, etc.), the office section (preparation of maps and sections, mineralogical and petrological work, polished section studies. etc.), and workshops for testing and repairing. The productive department is responsible for drilling, the mechanics being supervised by the District Geologists. The area is sub-divided into several districts. In peak period 70 boring machines were employed but during the author's visit 20 were in operation (KAM-500, Crelius and ZIF-300). More than 300 bore holes were sunk in an area of 150 square kilometers, the deepest being nearly 1,000 meters. The grid of bore hole was 75 x 100 meters, 75 meters being the distance between the bore holes along the strike. Ore reserves of categories A,B & C_1 are assessed as 120 million tons, capable of yielding 3—4 million tons annually. About 95 million Roubles were spent for prospecting in this area.

MINERAL EXPLOITATION

When a particular deposit has been proved by the Ministry of Geology and Conservation of Mineral Resources, it is handed over to the Ministry concerned for development and mining. As for instance, if a deposit of copper-ore is proved by prospecting by the Ministry of Geology, it will be subsequently worked by the Non-Ferrous Ministry who will make necessary arrangements for communications, road construction, building houses, mining, ore-dressing, etc. Further prospecting, however, would be continued by the Geologists working under the Non-Ferrous Ministry. Likewise, a deposit of iron-ore once prospected and proved by the Ministry of Geology will be developed and mined by the Ministry of Ferrous Metallurgy.

A group of important mines in a region is generally worked by the so-called special Trusts or Combines. A brief reference to some of the important mines and oil-fields visited may be given.

The Chaitura manganese deposit in Caucasus, the largest of its kind in the U.S.S.R., is worked by the Chaitura Manganese Trust of the Ministry of Ferrous Metallurgy. This operates several mines and nine beneficiation plants.

The Tyrnyauz tungsten and molybdenum mine in Caucasus is worked by the Combine of that name which also operates the beneficiation plant and other subsidiary installations. The Combine works under the Ministry of Ferrous Metallurgy. In 1937 adits and drilling from surface were commenced, and the prospecting still continues by cross-cuts and deep drilling from underground. The tenor of ore is the lowest worked anywhere in the world, and the working of this deposit signifies that they are determined to work even the exceedingly poor grade ores in the U S.S R which may not be considered economical to work in other countries of the world.

The Ministry of Coal is concerned generally with planning, organization and coal mining, and is also entrusted with mines design, coal preparation, research and manufacture of mining machinery and equipment.

The exploration for oil is the concern of the Ministry of Oil. The Ministry has six branches, i.e., Oil Refineries, Construction, General Organization and Technical Training, Land Oil Exploration, Off-shore Oil Exploration and Equipment, each in charge of a Deputy Minister.

UNITED KINGDOM

Geological Survey of Great Britain.

Founded in 1835, the Geological Survey of Great Britain is the oldest national geological survey of the world. Controlled by the Department of Scientific and Industrial Research, the Geological Survey has 90 Geologists although about 120 Geologists are actually needed. There is a Museum of Practical Geology attached to the Survey. The principal sections of the Survey are :—

(1) Palaeontological Department
(2) Petrographical Department
(3) Chemical and spectrographic Department
(4) Water Department
(5) Geophysical Department
(6) Atomic Energy Division.

Geological mapping is carried on a scale of six inches to one mile maps, covering 270 square miles annually by primary survey and 570 square miles annually by revision survey. An area of 25,000 square miles is yet to be covered in Great Britain on six-inch scale for the first time. Besides Memoirs, Bulletins, Summaries of Progress and Annual Reports, etc., the Geological Survey publishes the following geological maps :—

(1) Twenty-five miles to one inch maps of the British Isles.
(2) Ten miles to one inch maps of Great Britain.
(3) Quarter-inch to one mile maps of England and Wales.
(4) Quarter-inch to one mile gravity survey overlay maps of England and Wales.
(5) One-inch to one mile maps of England and Wales, New Series.
(6) Quarter-inch to one mile maps of Scotland.
(7) One-inch to one mile maps of Scotland.
(8) Six-inches to one mile maps.
(9) Quarter-inch to one mile maps of Ireland.

Colonial Geological Survey.

The Colonial Geological Survey (Imperial Institute, London) was founded in 1946 with a view to co-ordinate the Geological surveys in the British colonies, It also plans and assists geological mapping, soil surveys, mineral surveys, aerial surveys and geophysical surveys for the colonial geological surveys numbering twenty-one. The Mineral Laboratories of the Mineral Resources Division of the Colonial Geological Survey are of particular help to those overseas colonial surveys not having their own research or technical services. The British colonial welfare fund is available for financial assistance to the Colonial Geological Survey. Headed by a Director, who also functions as an Adviser to the British Government, the Survey has 25 senior scientists and a complement of technicians. The Survey maintains close liaison with the Geological Survey of Great Britain.

EAST GERMANY

A State Geological Committee in Berlin, with a network of regional bureaus, controls all geological work in East Germany. The Committee has two administrative branches. The Geology branch is responsible for geological surveys, mineral investigations, soil surveys and ground water investigations. The Exploitation Technique branch conducts geophysical surveys and drilling.

WEST GERMANY

Hanover Geological Survey

There is no central Geological Survey of the Federal Republic of West Germany. Six out of nine Federal States of the Republic have independent Geological Surveys whereas the rest have a joint Survey. Created in 1919 the Hanover Geological Survey is the important organization in West Germany with up-to-date laboratory and highly trained technical personnel. The department has 108 scientists (Geologists, Geophysicists, Soil-scientists, Geo-chemists, etc.). The Krefeld Survey consists of 120 Geologists and scientific workers.

Geological mapping is generally done on a scale of 1:25,000, and in case of detailed work mapping is done on 1·10,000 and 1:5,000 maps. Use of hand-augers and sinking of trial pits and drill holes are taken recourse to in clarifying problems. Geological maps on a scale of 1:100,000 are being published, each map having a corresponding published memoir. The publication of geological maps on a scale of 1:25,000, hitherto done by the former Prussian Geological Survey. has now been discontinued due to financial grounds. Usually mapping of soils is done on 1:25,000 scale, thus showing an uniformity with the geological maps, but maps are printed on 1.100,000 scale. Detailed soil mapping on a scale of 1:5,000 is done in important agricultural areas. In addition, hydro-geological maps, deposit maps and maps showing tectonic structures are also prepared. The geophysics division has various branches, namely, gravimetric, magnetic, seismic (reflection and refraction), geo-electric, radio-active and geo-thermal. A branch office of the geophysics department is located at Gottingen for undertaking geo-magnetic problems. The following are the principal departments of the Hanover Geological Survey :—

(1) Department of geological mapping & scientific work.
(2) Department for the development of all mineral deposits excluding oil and gas.
(3) Department for the development of oil and gas.
(4) Department for hydro-geological studies.
(5) Department of engineering geology.
(6) Department of Soil science.
(7) Department of mineralogy, petrology and geo-chemistry.
(8) Department of geophysics.
(9) Department of palaeontology.

The main functions of the geophysics department are as follows :—

(1) To give expert advice and information on geophysical problems to State Geological Surveys, Federal authorities, private firms and the public.

(2) To collect data on geophysical surveys throughout the Republic, including work of private enterprises and to utilize them for the preparation of geophysical and geological maps.

(3) To adopt all known geophysical methods in the State Surveys and to develop new techniques when tackling new problems.

(4) To offer a few months' practical training to students of geology and geophysics every year.

In the field of applied geology the Hanover Geological Survey performs the following tasks in close co-operation with universities and Geologists of various mining enterprises :—

(1) Search for mineral resources, opening up of deposits, advice on economical exploitation and utilization of minerals.

(2) Prospecting for ground water, for the needs of towns and industries, and dealing with problems concerning sewage disposal, irrigation and drainage, and designing of new tools and adopting new methods.

(3) Assisting the Engineers in town planning, erection of industries, road and canal constructions, improvement of rivers and coast, building of dams, etc., and designing of special implements.

(4) Soil studies to advice agricultural and forest exploitation.

Being a most thoroughly exploited country with regard to mining, industrial, agricultural and forestrial fields, the present emphasis is not on a mere geological basis but on specialization and adoption of modern methods and techniques.

Among the present day activities of the Hanover Geological Survey, particular mention may be made with regard to prospecting for oil and gas and coal. The success of a systematic research for oil, thanks to a thorough geological and geophysical co-ordination, is borne out by the great increase in the production of oil in Germany in recent years. The 1930 output of oil of whole Germany amounted to 174,070 tons. In 1954 the figure rose to 26,66,314 tons. Exploration for oil in West Germany was largely controlled by the Hanover Geological Survey. Reflection seismic method is being employed for oil field investigations. 22 reflection crews were in the field in 1950, and 36 both in 1952 and 1953. Expenditure for geophysical prospecting by the oil industry at 6-7 million Marks in 1950 rose to 18 million Marks in 1953.

Extensive geophysical measurements with gravimeter, torsion balance and seismic equipment gave information regarding the depth, dip and faults of the Tertiary base in coalfields. Thousands of bore holes were drilled and measured by "Schlumberger method" with a view to obtain a knowledge of the strata and the coal seams. In the Ruhr coal basin, the reflection seismic method solved various geo-tectonic problems.

FRANCE

Geological Survey

There is no organization in France akin to the Geological Surveys of other countries, and the responsibility of geological mapping rests upon the "Directeur du Service de la Carte Geologique de France". He determines the priority of the area to be geologically mapped and requests a Geologist in the State who might be available for the purpose. University workers may be thus associated with such work. The cost is borne by the Government.

Explorations for Minerals

The geological surveying and prospecting of mineral deposits in France are nowadays carried out through the following Government subsidized bodies :—

(1) Geological, Geophysical and Mining Research Bureau (BRGGM).
(2) Geology and Coal Deposit Service of the French Coal Mines.
(3) French Petroleum Institute.
(4) Atomic Energy Commission.

Established in 1953 the BRGGM is controlled by a Board of Directors, under the supervision of the Ministry of Industry and Commerce. It undertakes on behalf of individuals, mining companies and Government, geophysical prospecting, chemical prospecting and aerial surveying, in co-operation with other organizations (e.g., Bureau for Mining Research in Algeria, Mining Bureau for Overseas France, etc.), including universities and mining schools. The service has a documentation section (inclusive of underground mining data and drilling data) which offers information to the public, sometimes in the form of publication, maintains technical and scientific research laboratories, and has a mining and prospecting section. The prospecting section is fully equipped with drilling and geophysical instruments and is now working for ground water, coal, tungsten, columbite, copper, lead-zinc and uranium ores in several parts of France, and the recent finds of iron-ore in Bordeaux and Jura, oil at Briod (Jura) and pitchblende in the Massif Central, speak of achievement. The Bureau exchanges information with individuals, mining enterprises and private consulting organizations in a friendly spirit without going into competition. The Bureau can receive a share in the profits arising from working of mines developed as a result of prospecting and checks on the use of funds made available to organizations receiving its financial help. In addition to the usual technical personnel (executives), the Bureau maintains a register of Associates from the industry or learned societies or universities for consultation work.

The Geology and Coal Deposit Service of the French Coal Mines is operating at present in the coal basins of Nord and Pas-de-Calais, Lorraine, Loir and Garonne. The Geological Services of the Coal Basins deal with problems for large coal basins. "The Centre d'etudes et de recherches des Charbonnages de France", with a chain of laboratories, is an important research organization dealing with coal.

The Petroleum Research Bureau and the French Petroleum Institute are particularly concerned with oil field geology, prospecting, research, etc.

Although in France there are several independent organizations performing identical or allied tasks, the Geologists, Geophysicists and other workers of the several services meet very often to co-ordinate their work. Prospecting for minerals is also undertaken by private companies or enterprises.

III. EXPLORATION OF ORE DEPOSITS FOR FERROUS METALS

U. S. S. R.

Sarbai Iron-Ore Deposit.—The geology of the area consists of folded Palaeozoic rocks overlain unconformably by Mesozoic and Cenozoic formations. The Palaeozoic rocks strike NNE-SSW in conformity with the regional direction of the Urals. The iron-ore occurs at the contact of sedimentary, volcanics of Lower Carboniferous with a diorite intrusion. Metamorphosed rocks along the contact, with more than 50% Fe, represent high grade ore. Skarns comprise 30-50% of the deposit and low grade ore forms 20-30% of the deposit.

There are three ore-bodies. The eastern zone runs for 1,500 meters along the strike and has been proved up to a depth of 800 meters. The south-eastern ore-body merely represents an extension of the eastern one and is displaced due to faulting. The western ore-body extends over a length of 1,000 meters and has been proved to a depth of 600-650 meters. The origin of ore is attributed to contact metasomatism.

The chief ore is magnetite, in association with pyrite, pyrrhotite, and rarely chalcopyrite and sphalerite. The gangue consists of pyroxene, garnet, scapolite, actinolite, epidote, chlorite, quartz, zeolite and apatite. In addition, there are secondary ore minerals in the oxidized zones.

The ore has the following average composition : 41.61% Fe, 3.8% S and 0.13% P. It is amenable to wet and dry magnetic separation, and sulphur can be roasted off. The technological data are given below : —

	%	**Fe-content**	**Fe-recovery**
Ore		44.0%	-
Ratio of dry magnetic separation	30	58.0%	39.6-83.7%
Ratio of wet magnetic separation	31.6	61.5%	44.1%
Tailings	38.4	18.6%	—

Krivoy Rog Iron-Ore Basin.—The geology comprises highly folded Pre-Cambrian iron-bearing quartzites, chloritic shales, talc-schists, phyllites, sandstones and migmatites. The fold axis trends NNW-SSE. The Pre-Cambrian rocks are overlain at places by horizontally bedded, 33-110 meter thick, loose silt and sandstones of Tertiary and Quaternary age.

The iron-ore consists chiefly of hematite, martite, and magnetite, in the form of massive ore-bodies or as every grade of mineralization in quartzites. The origin of ore is attributed to metasomatism of the quartzites by hydrothermal solutions. The high grade ore contains 46-69% Fe, and low grade ore 25-46% Fe, 3-8% SiO_2, 0.0042-0.005% P, Mn—trace, and S—trace.

In Krivoy Rog basin there are 15 opencasts, 40 underground mines, 20 ore-dressing plants, one steel plant, one coke plant and one mine machinery plant. The Giant mine visited by the Group is one of the biggest underground mines of the Soviet Union, located at the south of the basin. About 90 kilometers long along strike, the deposit represents a geosynclinal fold. The width of the deposit varies from 500 to 1,000 meters and its thickness is 180 to 200 meters. The deposit persists beyond a depth of 600 meters The ore reserve is estimated at 36 million tons inclusive of low grade ore. The daily output from the mine is 15.000 tons.

The mining methods at Giant mine comprise block caving (40%), sub-level caving (40%), stoping (3%) and other methods (17%). The levels are at 160, 270 and 300 meters. Mining is fully mechanized by electrically driven machines with various automatic controls of haulage and scrapers. The communication is done by carrier telephone. There are two skip shafts with provision for 5-ton trucks, and dumping devices for 3-5 ton trucks in the galleries. There are automatic scrapers of 200-ton capacity per shift of 8 hours, to scrape the ore to the chute and thence on to haulage wagons. The ore-dressing plant when completed will be the largest in the Soviet Union. Some data of the plant are given hereunder.

Capacity of cone crusher	1,500 tons/hr.
Capacity of first stage Magnetite Separator	30 tons/hr.
„ „ third „ Magnetite Separator	12 tons/hr.
Percentage of Fe in the concentrate	60-62%
Percentage of SiO_2 in the concentrate	14-20%
Agglomerate size	50-100 mm diam.
Percentage of Fe in agglomerate	56-58%
Percentage of SiO_2 in agglomerate	14-20%
Amount of ore treated	9,000,000 tons/annum
Amount of ore Concentrate produced	4,500,000 tons/annum
Amount of ore Agglomerate produced	5,250,000 tons/annum
Average cost of agglomerate	40 Roubles/ton

Kremenchung Iron-Ore Deposit :—Located on the ancient terrace of the Dnieper river, the deposit is 75 meters above sea level. The geology comprises grano-diorite (Lower Archaean), meta-basalt (Upper Archaean), sedimentary complex (Permian, Triassic and Jurassic) and granite (youngest rock). The ore occurs in Pre-Cambrian rocks of the Krivoy Rog basin. Judging from geophysical prospecting, the thickness of the ferruginous quartzite is 50-200 meters. The deposit extends over 4 kilometers and its maximum thickness is 70 meters.

The ore minerals consist of iron-mica martite, martite, hydro-hematite martite, chloritic martite, carbonate martite and hydro-hematite. The principal ore comprising 70% of the ore-body is hydro-hematite martite. The ore contains 60% Fe and 8% $Si0_2$, sulphur and phosphorus being very small. The origin of the deposit is attributed to hydrogenous replacement.

Chiatura Manganese Deposit.—Located in the Caucasus region in the Republic of Georgia, it is the most important manganese deposit so far known in the U.S.S.R. It lies in an area of a much dissected plateau, the highest point being 800 meters above sea level. The river bed in the mining area is about 350 meters above sea level. The mines are located between 500 and 800 meters above sea level.

The deposit is in the form of a flat-lying bed of Oligocene age, 1.5 to 4 meters thick, covering an area of some 150 square kilometers. It is sometimes undulatory and is at places faulted with throws varying from 3 to 20 meters. The source of manganese is attributed to granite and quartz porphyry in the neighbouring areas. Manganese from these rocks was dissolved, transported and precipitated as replacements of the sediments of Oligocene age. As such, the manganese horizon often preserves the relict-bodies of unreplaced bedded sandstones and clays. It is underlain by limestone and occasionally sandstone, and overlain by sandstones and sometimes other sedimentary rocks of Cenozoic age, the maximum thickness of the overburden being up to 200 meters. The principal ore minerals are pyrolusite and psilomelane.

The Group visited the Lenin mine of the Chiatura Manganese Trust, where longwall system of mining is practised. The length of the longwall face is 40 meters, the daily output in a face being 250 tons per day. Cross-cuts have the dimension of 3 meters x 4 meters, large enough for the scraper loading equipment. The capacity of the scraper is 120 to 150 tons per shift. About 90% of ore is extracted in mining.

Aerial cableway is used for taking ore from the mines to the ore-dressing plants. There are altogether 9 beneficiation plants of the Trust. The plant attached to the Lenin mine yields 3,000 tons of concentrates daily. The composition of crude ore and concentrate is tabulated as follows :—

	Crude	**Concentrate**
Mn	32-35%	45-50%
SiO_2	20-25%	10-15%
Fe	up to 3%	1.5-2%
P_2O_5	0 2%	0.2%

The crude ore undergoes various stages of crushing, screening and washing. 100 tons of crude ore yields 56 tons of concentrated ore. The washed ore is classified as follows :—

0-1.5 mm.	...	51% Mn
1.5-12 mm.	...	"
12-20 mm.	...	48-49% Mn

The best grade ore is used for chemical and electrical industry. Ore containing 45-50% Mn, graded as the first class ore, is utilized for the manufacture of ferro-manganese. Low grade ore containing 25% Mn and above is used for blast furnace.

Tyrnyauz Tungsten & Molybdenum Deposit.—Situated in Caucasus region, the main mine is located at 2,757 meters above sea level. The geology consists of Pre-Cambrian schists and limestones, and granite. The deposit is about 1.5 kilometers in length, outcrops being noticed at 2,700-3,500 meters above sea level. Mineralization persists up to 800-1,200 meters from the surface. The thickness of the ore-body is 100-150 meters at the central part and 2-5 meters at the flanks. The ore-body dips eastward and is formed by contact metasomatism. The ore reserve is calculated at 126 million tons.

Scheelite and molybdenite constitute the ore minerals. The gangue consists of quartz, epidote and garnet. Powellite and molybdenite occur in the zone of oxidation. On an average the ore has the following composition : 0.14-1.3% $CaWO_4$ and 0.045-0.22% Mo, with traces of Cu, Au and Ag.

The four adit levels are : first level (2,817 meters above sea level), second level (2,757 meters) third level (2,682 meters) and fourth level (2,607 meters). In addition, there is another adit level which is not worked. A blind vertical shaft, 210 meters deep, connects the 3 levels. In addition there is another 120-meter deep blind shaft above the first level.

The vertical distance between the main haulage levels is 75 meters. In addition there are sub-levels of secondary crushing, 8 meters above the main level, and another sub-level of ore breaking 8 meters above the first sub-level. There are pneumatic loaders with a capacity of 10-50 cubic meters per hour. Ore is loaded off into the mine cars through chute and loading hatches. Mine cars have a capacity of 2.5-5 tons. The ore is hauled at the surface by electric train. There are two sets of aerial ropeways between the adit mouths and the ore-dressing plant, a distance of 2-5 kilometers. Altogether there are 5,000 workers, the number of underground workers being 800.

The ore after grinding in four ball mills is lead to classifiers. By the use of flotators (No 5 mechanical), the molybdenum concentrates are recovered first and then the tungsten concentrates. The tungsten concentrates contain 60% WO_3 and the molybdenum concentrates 15% Mo. The daily yield of ore and concentrates is as hereunder :—

	Amount	Tenor
Crude ore ...	5.500 tons	(0.14-1.3% $CaWO_4$) (0.045-0.22% Mo)
Tungsten concentrates ...	15-18 tons	60.62%WO_3
Molybdenum concentrates ...	5-6 tons	47-52% Mo

FRANCE

Lorraine Iron-Ore Basin.—In 1954 France ranked third among world producers of Iron-ore, and produced about 44 million tons. In the same period, the U.S.A. produced 85 million tons and U.S.S.R. 63 million tons. Reputed to contain a reserve of 6,000 million tons of iron-ore amounting 75% of the French iron-ore reserve, the deposits in the Lorraine basin extend over an area of 100,000 hectares. They are uniform and almost horizontally bedded, the ore being called "minette" with Fe content of 32%. Sedimentary in origin, the deposits are 20-60 meters thick. The workable bed is a calcareous one with a thickness of 3-7 meters, although siliceous bands are also present. The ore is self-fluxing and is thus easily treated in blast furnace.

The Lorraine mines employ 25,000 workers in 30 companies. The mines are highly mechanized, and yet further mechanization is in progress. The mining companies will have to invest 30,000 million Francs more during next few years to replace rolling stock and bring mechanical loading from 90% to nearly 100%. 7,000 million Francs will be spent for accommodating workers. It is proposed to produce 50 million tons in 1958 with 48-hour a week shifts, without increasing the labour force. The productivity of the whole operation will be 9 tons per man, the most uptodate capacity in the world being 11 tons.

In France there has always been inadequate quantity of hard-coking coal and high grade iron-ore, a drawback in the country's steel industry. However, further development is visualised in view of recent progress of processing metallurgical cokes from low grade coal from Lorraine basin and of treating low grade iron-ore of the same basin. The mining companies work in co-operation with the Technical Services of the Institute of French Iron Mines and Society for the Study of Mechanical Loading in Lorraine Iron Mines (S.E.C.N.)

Bazailles Iron-Ore Mines.—One of the best mechanized mines in the Lorraine basin, this mine works for "Minette" or oolitic hematite containing 30-36% Fe. The ore is calcareous in the upper part and partly siliceous in the lower part. The mine covers an area of 3,000 hectares and has a reserve of 300 million tons. There are 9 bedded ore deposits but only 2 are mined at present. The ore analyses are as follows :—

SiO_2	...	12—15%
CaO	...	4— 5%
Fe	...	34%
P_2O_5	...	1.5%
Al_2O_3	...	3—4%
S	...	0.1%

The mine employs 450 workers, 100 working on the surface. Room and pillar method of mining is followed, taking recourse to roof bolting and drilling-on-jumbos. Shovels, scrapers, conveyors and joy-loaders are used for underground loading. Shuttle cars and electric locomotives are used for haulage. There are 2 shafts. The 172-meter shaft is used for ore haulage by 14-ton skips, and also functions as the upcast. The second shaft, 110-meter deep, is employed for men and material and haulage with cages, and is also used as the downcast shaft. The pit-head cost of ore is 800-900 Francs per ton.

WEST GERMANY

Salzgitter Iron-Ore Deposit.—The iron-ore deposit is of Neocomian age having the following three stages :—

(1) **Hauterive.**—The so-called oolitic "brown deposit" of the Hauterive, with a thickness of 20-30 meters, is the chief ore deposit. It is worked by opencasts as well as by underground mining.

(2) **Barremian.**—The residual ores and the ores having a conglomeratic structure belong to the stage.

(3) **Apt.**—The clayey "red ore", mostly oolitic, is not economically workable.

The ore is principally a limonite. The residuals and boulders are re-conditioned argillaceous iron-ores or sphaero-siderites, derived from the re-conditioned Lias and

Dogger beds, with a size of 0.1-0.3 meter. In the groundmass, chamoisite ore, kaolinite, hematite and goethite are present. Calcite and organic calcareous fragments form the secondary constituents of the ore. Some siderite is present and mica occurs in small flakes. Magnetite and maghemite are indicated from X-Ray.

In Salzgitter Bad the ore deposit, 100-meter thick, is present up to a depth of 1,300 meters. Further to the east the deposit persists from the Flachstockheim salt dome to the Fallstein saddle. A thin Quaternary cover is present at places, otherwise elsewhere the ore deposit is blanketed by 1,200-meter thick Lower and Upper Cretaceous rocks.

Haverlahwiese Opencast.—Located on the western flank of the Salzgitter mountain range, the deposit is worked along a length of 3,000 meters and up to a depth of 100 meters. The deposit below a depth of 750 meters is worked by underground mine. The deposit is 30 meters thick on an average and dips at 65°. The ore analyses are as follows :—

Fe	...	30—31.5%
SiO_2	...	23 5—25%
CaO	...	4—4.5%
P	...	0.4%
Mn	...	0.2%

The output from both opencast and underground mine is 18,000 to 20,000 tons daily, the latter yielding 2,500-5,000 tons daily. There is a drag line for winning of ore and another drag line for stripping the overburden. The ore haulage is done by 75-ton normal gauge freight cars with the help of shovel-dredgers, bin-wagons and a power shovel.

Calbecth Ore-Dressing Plant.—An auxiliary of the Salzgitter Erzbergbau A. G. the plant comprises the following units :—

(1) Wet dressing plant with a capacity of 16,000 tons per day.
(2) Float and sink plant with a capacity of 3,200 tons per day.
(3) Sintering plant with an output of 7,000-8,000 tons of sinter per day.

IV. EXPLORATION OF ORE DEPOSITS FOR NON-FERROUS METALS

U. S. S. R.

Shing-Magian Antimony-Mercury Deposit.— Situated in a rough terrain of the Gissar Mountain Range, in Tadzik Republic, the deposit is located at 2,500-3,200 meters above sea level. Palaeozoic rocks are common sedimentaries, and igneous rocks include minor grano-diorite, lamprophyres and porphyries intruding the sedimentaries. The geology is complicated by faults, overthrusts and folds. Ore (stibnite) occurs in breccias, along zones of regional displacements. The thickness of the mineralized zones ranges between 1-2 meters and 60-70 meters.

Reserve to date is estimated at 150,000 tons of antimony, 50,000 tons belonging to category B and above. Five important mineralized areas are reported to occur, and the Group examined the Turk-Parida deposit, where the mineralized breccia is found at the contact between limestones and shales, over a length of 2,000 meters along a NE-SW strike. The breccia dips at 25°—50° north-west and is 39 meters thick. It contains on an average 3.5% of stibnite.

Chal-Atin Lead-Zinc Deposit.—The deposit is located in a mountainous terrain in the Kalamanza district in Uzbek Republic. Originally the area was mapped on a scale of 1:10,000, followed by detailed mapping on a scale of 1:10,000. A sum of 300 million Roubles was spent for prospecting.

The regional geology consists of Devonian limestones overlying Silurian rocks, hypabyssal rocks (andesite, liparite, dacite, etc.), grano-diorite porphyry, granite porphyry, etc.

Mineralization is generally restricted in skarn rocks at the contact between limestones and grano-diorite porphyry and associated dyke rocks. The origin of ore is believed to be due to high temperature metasomatism.

The deposit consists of the following types : strike, vein, disseminated, breccia, massive and mixed, the first two types being predominant. The principal minerals are galena and sphalerite. The average lead content of ore is about 2.5%, and Zn content is normally higher in ores with lead content above 0.7%.

Dergtyarsk Copper Deposit.—Situated in the Urals region, 85 kilometers south-west from Sverdlovsk, the deposit is being worked since 1937 by the Mining Trust of Dergtyarsk. The mineralization is restricted to a zone of fracture between Silurian shales and quartz-albite porphyry. The ore zone is 5 kilometers long and 120 meters wide at the thickest part, and dips 60°—70° east.

The ore consists of pyrite, sphalerite, chalcopyrite, arsenopyrite and covellite, and the gangue minerals comprise quartz, barite, calcite and cerussite. The copper content of the ore varies from 1 5-2.5%. The ore reserve is estimated at 80 million tons. The mine maintains a Geological Prospecting Bureau headed by the Chief Geologist, who also concurrently works as the Mine Superintendent. The scale of underground mapping is 1:50.

Underground mining is done at 3 principal levels, namely at 130 meters, 190 meters and 250 meters, taking recourse to sub-level caving for mining. The total number of workers is 7,000 inclusive of 3,500 underground workers. The daily output of ore is 8,000 tons. The mine does not possess any treatment plant.

FRANCE

Lead-Zinc Deposit at Chitry-les-Mines Yard.—Reputed as an old silver mine during the fifteenth century, the area is being prospected for lead and zinc by the Bureau of Research in Geology and Geophysics for Minerals (BRGGM). The country rocks comprise limestone and some intrusive granite, the mineralization following the fracture zones in the former.

During the visit, geochemical prospecting was being conducted by a party of 1 chemist, 4 samplers and 4 persons for preparation of the samples. There are two trucks with a small chemical laboratory. The main object is to collect data for the preparation of a geochemical anomaly map to determine the mineralized zones. The other objective is for guidance in mapping and locating trial pits and trenches. 50-gram soil samples are collected in a grid pattern of 20 meters from a depth of 20-30 centimeters The samples are analysed for lead, copper and zinc content, following the usual colorimetric method.

Lechaux Uranium Mine.—Discovered in 1949, the Lachaux Uranium mine is being worked under the direction of the French Atomic Energy Commission. The technical personnel consists of 3 Mining Engineers, 1 Geologist, 1 Prospector and 10 Foremen. There are altogether 150 workers at the surface and underground. The present work is in the nature of exploratory mining and includes boring, shaft sinking and driving of several levels and cross-cuts in the zones of mineralization. To date, the exploration has cost about 250 million Francs. Besides, radiometric prospecting of all the surface rocks is also carried out by the prospectors. One prospector can cover about 8 square kilometers every month.

The area is mapped geologically on a scale of 1:50,000 by the service of the Geological Map of France. A large scale geological map on a scale of 1:10,000 shows the geology of the terrain in a greater detail. The area comprises the so-called granite of the North Forez, and includes granite porphyry, micro-granite, ortho-gneiss and fine-grained granite. The mineralization follows the trend of the Hercynian disturbances (Tertiary) and generally runs NW-SE. It is particularly developed along or between faults, the maximum length of the mineralization recorded being up to 5 kilometers with interruptions. The maximum width of the mineralization is about 20 meters. The ore-bodies have been so far followed down to a depth of 200 meters and appear to persist at greater depth.

The ore-bodies are in the form of irregular veins or disseminations along crushed zones or faults in the granitic rocks, particularly at the contacts between fine-grained granite and micro-granite and between granite-porphyry and micro-granite. The most important ore is pitchblende with small amounts of torbernite and autonite. Traces of chalcopyrite and galena are also present. The gangue consists principally of quartz (pink, white and smoky) and feldspar. Quartz is of two generations, namely the older ore-bearing quartz and the younger barren quartz. The mineralized zones are vertical or steeply dipping between 65° and 75°. The maximum length of mineralization proved at one place is about 500 meters.

Systematic exploratory work began in July, 1954. The total length of exploratory tunnels is of the order of 3 kilometers. The deepest shaft is 230 meters below the surface and there is a second shaft some 30 meters deep. The levels are located at depth of 70, 80, 160 and 200 meters from the surface, and are driven along the zones of mineralization. The 80-meter level has been connected to an old copper mine which was worked about 40 years ago. The various levels and cross-cuts are mapped on a scale of 1:500.

Bore holes are being sunk by the Atomic Energy Commission, and the Geiger counters are made and developed in their own laboratory. The depth of boreholes drilled to date ranges from 50 to 200 meters. The diameter of the cores are 56 to 100 mm. Some angle bore holes have been also drilled.

The ore from the mine is graded into 3 categories, namely, poor ore, good or average quality ore, and rich ore. Ore from the mine is tested in small truck loads in a testing shed where a special built-in Geiger counter records the quality of the ore according to certain standard of grading.

About 40 tons of run-of-mine ore are being treated daily as an exprerimental measure in a processing plant located about 20 kilometers away from the mine. The ore is transported by trucks. This plant was once used for beneficiation of the uranium-bearing ore from a mine in that neighbourhood which was completely worked out. The uranium content of the Lachaux mine ore which is treated varies considerably and ranges from 0.6% to 38% U_3O_8. About 10 tons of concentrate containing 2% uranium are recovered daily and the tailings containing 0.02% of uranium are led into a reservoir at the foot-hills. Flotation process is used for the beneficiation of the ore.

WEST GERMANY

Mechernich Lead-Ore Deposit – Located in the Trias of the Nordeifel imbedded as a large bay into the Devonian formation, the lead-ore deposit of Mechernich is reported to contain about 2 million tons of metallic lead, equivalent to some five per cent. of the world's known lead reserves. The ore, however, is the poorest mined anywhere but exists in large quantities. The lead content varies from 1 to 2.5 per cent. The mining district is 10 to 12 kilometers long and 1 to 2 kilometers wide, and the ore reserve amounts to at least 100 million tons.

The ore is associated with the Middle Bunter sandstones and conglomerates. The mineralization is connected with some hydrothermal solutions permeating the bedding planes and numerous fissures in the country rocks. A mineralized sandstone bed, 30 meters in thickness, between conglomerates, is present in the eastern part of the deposit In the south-western part, there are several 4 to 6 meters thick conglomerate beds intercalated within the ore-bearing sandstone bed. The sandstone consists of quartz grains cemented by siliceous, argillaceous or calcareous matrix, whereas the conglomerate comprises boulders of quartzites, quartz and graywacke.

The ore mostly comprises galena and cerussite, whereas anglesite, pyromorphite and crocoite constitute small amounts. The main mineralization is in the matrix of the quartz grains of the sandstone and the pebbles of the conglomerates. The ore also occurs in the form of so-called knots which are concretion of lead ores up to 5 mm. thick. The distribution of knots is irregular.

Ancient mining in this area is known since the time of the Celts and Romans. Large scale exploitation began since 1859 and in 1911 the Gewerkschaft Mechernicher Werke was founded. In 1937, the Gewerkschaft was taken over by the "Preussiche Bergwerks-und Huttern—A. G." but the project was interrupted by the war. In 1947, reconstruction and modernizing of the mining and ore-dressing commenced, leading to the resumption of large scale opencast mining. Ore-dressing and smelting started in the following year. The entire industry is now State owned. The underground mining was resumed in 1948.

The ore is mined both by opencast (60%) and underground operations (40%). Formerly the haulage from the underground was done by a shaft hoisting equipment with the aid of a steam-winding machine. Since 1953 a modern skip winding with an electric tower winding machine is in operation. The opencast mining was formerly connected with the dressing plant by an aerial tramway, but in 1952 it was replaced by a standard gauge railway. The present output of ore is about 6,000 tons per day. The labour force is over 1,400.

The four types of treatment used in the dressing plant are as follows :—

(a) Selective disintegration by means of impact crushers The plus 8 mm. fraction is regarded as barren gravel (crude ore consists of 30-40% of gravel).

(b) Treatment of the grain sizes 1 mm. to 8 mm. is in heavy medium cyclones which give a very high metal recovery.

(c) After hydro-classification removal of barren silica sand, size 0 5 mm. to 0.1 mm., is done on Humphre's spirals.

(d) After grinding the remaining 46% of the crude ore in ball mills, flotation is done in separate circuits for coarser ore and primary slurries. The lead concentrate contains 65 to 70% lead.

The total metal recovery is 80%. At present the output of the concentration amounts to 34 3 tons per man per shift. The power consumption of the plant is about 10 KWh ton of ore.

The concentrates are smelted in a plant in the vicinity. The monthly production of lead amounts to 1,100 tons per month. Some amount of refined silver, with a little proportion of gold, is also recovered as a by-product. The smelter has a capacity of 1,300 metric tons a month. In addition to lead, monthly production includes some hundreds of kilograms of auriferous fine silver, and cuprous and antimonial by-products.

Rammelsberg Lead-Zinc Deposit.—The lead-zinc ore-bodies occur as embedded lenses in Devonian slates, the ore minerals being chiefly galena, sphalerite, chalcopyrite and pyrite. The ore is very fine-grained and is finely disseminated. Barite and calcite form the usual gangue.

Two types of ore are mined, namely, 'reich erz" or high grade ore and "band erz" or low grade ore. The high grade ore has the following assay values : 8-10% Pb, 1%Cu, 17-20% Zn, 9-10% Fe, 20-25%$BaSO_4$, 1g/ton of Au and 160 g/ton of Ag.

The low grade ore comprises alternating layers of slate and ore around high grade ore bodies. Its average assay value is 3.5% Pb, 0.5% Cu, 6.7% Zn and 6-8% Fe.

A third type of ore-body (Kneist) occurs between clay slate and quartzite sandstone in the hanging walls. It shows both primary and secondary mineralization and its metal content averages 1.5% Pb, 1.3% Cu and 3% Zn. It is also associated with some pyrite.

The mine works only high grade and low grade ores and has developed up to the 720-meter level, the interval between levels being 40 meters. Overhead stoping with back filling method is employed in mining, and only battery operated locomotives are worked underground for safety reasons.

The dressing of high grade and low grade ores is done separately on account of the difference of their composition and dissemination. Extensive process of milling is required in case of complex ores. The Rammelsberg mill with a capacity of 650 tons per day treats the rich ore, whereas the Bollrich mill with a capacity of 400 tons per day treats the low grade ore.

After crushing and grinding process the high grade ore is subjected to selective flotation in 4 circuits, namely, (1) lead-copper circuit, (2) zinc circuit, (3) pyrite circuit, and (4) $BaSO_4$ circuit. The metallurgical data are as hereunder :—

Product	Pb %	Cu %	Zn %	Fe %
Mine ore	8.5	1.05	18.3	9.5
Pb-Cu concentrate	32.5	3.05	18.4	12.7
Zn concentrate	6.9	1.00	44.2	7.8
Pyrite concentrate	3.7	0.80	6.9	27.3
Tailings	0.8	0.08	0.9	5.3
Recovery	67 9	61.20	76.0	—

The low grade ore after crushing and grinding at the Bollrich mill is subject to selective flotation in 3 circuits, namely (1) lead-copper circuit, (2) zinc circuit, and (3) pyrite circuit. The metallurgical data are given below :—

Product	Pb %	Cu %	Zn %	Fe %
Mine ore	4.2	0.4	7.9	7.8
Pb-Cu concentrate	31.7	2.9	16.6	13.9
Zn concentrate	6.6	0.6	42.8	7.7
Pyrite concentrate	6.1	0.5	9.2	24.8
Tailings	1.0	0.05	1.0	5.4
Recovery	59.2	62.9	66 5	—

V. EXPLORATION OF FUEL DEPOSITS

U. S. S. R.

INTRODUCTION

The principal coalfields in the Soviet Union are as follows : Donetz basin, Moscow basin, Kiziozkiev basin, Uzbek basin, Karaganda, Kuznetsk basin, Molotov basin, Georgia, Kirghiz and Turkmenia. The Donetz and Kuznetsk basins, containing chiefly bituminous coal, are the largest in the U.S.S.R. Lignite or brown coal is particularly important in Moscow basin and in the Urals. Among the recently developed new areas of coal are Boskrik, Turgii, Saranski, Dolenski, Karaganda and Ushinski, and 60 new deposits are proposed to be explored in the next five years. The target for coal output in the Soviet Union for 1955 was set at 300 million tons of coal (25% coking coal) and 90 million tons of lignite.

The age of coal deposits is from Carboniferous to Triassic, the gas content of coal ranging from 12% to 60%. The gas coals are classed into four groups (gassy with highest volatile content, category 1, category 2, and category 3). The average calorific value is about 9,000, and sulphur content ranges from a trace to 0.5%.

Located largely within the limits of the Ukrainian Republic, the Donetz basin is the most important coalfield in the U.S.S.R., although its output is in the decrease as a result of developments in other local basins. It is 350-400 kilometers long and 120-150 kilometers wide, and has an area of some 50,000 square kilometers. There are 300 coal seams, 0.45 - 2 meters thick, with gentle to moderate dip in the west and steep dip in other parts. So far 70 seams are said to have been worked. The coal is Carboniferous in age and is gas coal to anthracite in kind. The reserve is estimated at 55,000 million tons. Altogether there are 400 coal mines yielding 115 million tons annually, 50% being coking coal. Largely destroyed in World War II, but rehabilitated after the war, the coal mines of Donetz basin in seven years produced 1.6 times of the output before the war.

Mining Method.—Opencasts are in operation in the Urals, Siberia and the Far East. Bituminous coals and lignites, with 3 to 100-meter thick seams, are worked by opencasts. Besides, underground mining, hydraulic mining and underground gasification are also practised. Various types of coal cutters, loaders, conveyors and other equipment are in common use.

First commenced in 1930 and subsequently expanded during World War II in Tilgon and Polyskisa, hydraulic mining is being planned in the Donetz, Uzbek and Karaganda basins. According to Soviet Mining Engineers, this method augments the output by 4-5 times more than other methods of mining. A monitor squirting water at 70 atmospheres is said to be most effective, and monitors capable of producing 150-atmosphere pressure are being constructed. Coal is conveyed by water to sumps, elevated by pump to setling tanks at the surface, dried and processed. Recourse to blasting is taken only in case of hard coal.

The earlier experiments for underground gasification of coal, dispensing with underground mining and attendent risks, date back from 1936, and several experimental underground gasification units were constructed in World War II in the Moscow and Uzbek basins. A series of bore holes in a regular pattern is drilled, and combustion is set in the coal seam, and air pumped down to maintain combustion and generation of gas. Gas is drawn off from outlet bore holes. The holes are 50-70 meters deep, and their spacing depends on the character and moisture content of the coal. One ton of coal is reported to yield 700 cubic meters of gas.

Price & Production Cost.—The price of coal in the Soviet Union is about 57 Roubles per ton. The cost of production of coal is stated to be as follows :—

Opencast mine	...	12-18 Roubles/ton
Underground mine	...	30 Roubles/ton
Mines having a complicated geological structure	...	100 Roubles/ton

The Soviet Government desires that each Republic should be self-sufficient in coal, and therefore the cost of production varies from place to place. Production is maintained even if the cost is high.

Organization of the Coal Industry.—The Ministry of Coal is responsible primarily for planning, organization and coal mining, and is also connected with mines design, coal preparation, research and manufacture of mining machinery and equipment. Matters affecting supply, distribution, marketing and processing are dealt with by other Ministries. Coal mining in the Soviet Union is developed according to a five year plan, through the agencies of special Trusts and Combines, each Trust having 15 to 20 mines within its jurisdiction. Several Trusts may work together under the authority of a Combine. The Ministry operates 1,827 big coal mines, their daily individual output varying from 300 to 7,000 tons. The designing and manufacture of machinery and mining equipment are done through various research organizations, and proceed ahead of the needs of the coal mining industry.

Research.—The function of the various research bureaus is to design and manufacture mining equipment according to the needs of the industry. In 1955 the value of mining machinery exported to China, Poland, Hungary, Rumania, etc., amounted to 2,370 million Roubles. The designing of coal mining machinery is the particular concern of the special bureaus in the Donetz, Uuzbek and Moscow basins, Leningrad, Stalino and Voasebez, under the control of the Central Scientific Research and Design Bureau in Moscow.

The coal mining equipment and safety devices are the concern of the Moscow All Union Scientific Coal Research Institute. The treatment and coal dressing are dealt with at the Moscow Scientific Research and Design Bureau, with branches in Cheliabinsk, Georgia and Karaganda. In addition there is a Scientific Coal Research Institute for safety measures near Stalino and two institutes for mine surveying and scientific research in Leningard.

Working Conditions & Wages.—There is only one production shift, and one or two shifts for maintenance and preparation. 55% of all coal mines work two shifts and 45% three shifts, and the duration of shift varies from 6 to 8 hours. The duration of face workers is one to two hours less than surface workers. In under-ground, women operate signals, hoists, trucks, pumps and winding gears. Their number is being gradually decreased since 1945 as Trade Unions do not encourage women workers underground, and as a result of Government policy to replace women with men. Many women, however, at times like to have underground assignment owing to high wages, at times 3,000 to 4,000 Roubles per month

An underground worker gets 1,500 to 1,600 Roubles per month, a coal face worker 2,200 Roubles per month, and a skilled miner 5,000-6,000 Roubles. 65% of miners are paid on piece work basis and 35% on time basis.

Bonus is paid for any extra work or output. For long service, extra payments are made from 10% of the basic wage for one year up to 30% for 10-15 years. Long and meritorious service is rewarded by medals, the highest award for miners being the Order of Lenin. A miner is entitled to a pension equal in value to half of his normal basic wage, on the completion of 20 years service and on attaining 50 years. In addition there are other insurance benefits and educational facilities for dependents. The miners get free coal, medical service, and clothes at cheap rates.

Industrial Disputes.—Complaint from workers to the management is done through the local Party Organization and the local Trade Union. A three-man special conflict commission consisting of representatives from the local Trade Union, management of the mine and workers usually arbitrates difficult cases of industrial disputes. The cases may be referred to the district and regional authorities in case the decisions of the Commission are not accepted by both parties. The cases may be referred to higher levels in Moscow up to the Minister of Coal. In case of disagreements at that level, a Special Commission is constituted to settle the issue and its decision is final.

Nikitovka 4/5 Coal Mine (Donetz)

Operated by the Central Coal Trust of Donbass, under the authority of the Ministry of Coal of the Ukrainian Rupublic, the mine is situated 70 kilometers north-east of Stalino. It was destroyed in World War II and rehabilitated in 1944. The mine covers 13 square kilometers and has two 390-meter deep shafts called No. 4 and No. 5.

Out of 21 seams 13 seams are workable. The seams are 0.4 to 1.4 meters thick and dip 50°- 65°. The coal is coking and analyses as follows : moisture 5%, volatile 35% and ash 20-25%.

There are three underground levels, the 370-meter level being the deepest. Mining is done by longwall method without packing, and there were 20 working faces in operation during the visit. Work is done generally by coal picks yielding 3,000 tons daily. A PK-1 Combine and a heading machine (Sh BM) are being tried where there is room for mechanization.

Coal from the longwall face is moved by gravity drops. Battery locomotives are in operation on the levels. The mine car is of type VC-4. The skip winding is operated by a 800 KW, AC winding machine, the capacity of the skip being six tons.

The productivity of workers is 1.02 tons per man per day, the productivity at the working face being 6 tons per man per day.

The pit-head cost of coal is 80 Roubles per ton, preparation cost is 29 Roubles per ton, and selling price is 160 Roubles per ton. Raw coals are graded at the dressing plant as follows :—less than 0.5 mm, 0.5 mm to 10 mm and 10 mm to 25 mm. Coal smaller than 0 5 mm is subject to flotation, the fine coal having 7-8% ash.

Mushketovskayar Vertical Coal Mine (Donetz)

It is worked by the Budennovugol Trust The seams belong to the Smoleniov suite of the Donbass. Out of 10 workable seams only two seams 0.5 to 1.2 meters thick are worked. The seams are steeply dipping as a result of folding, and faults are very common. The Post-Carboniferous beds from Triassic to Quaternary overlie unconformably the Middle Carboniferous coal seams. The reserve is estimated at 11 million tons (A and B categories) and 22.5 million tons (C and C_1 categories) Analysis : 22% carbon, 0.5-0.6% sulphur, 5% ash, 34-40% volatile and 1 8% moisture.

There are three shafts to a depth of 420 meters. Mining is by longwall system, using Donbass—1 Combine and Combine UKMG-2. Chain conveyers (SKR) are in operation at the longwall faces, and battery locomotives are used in the levels and cross-cuts. All workers are provided with gas masks and special gas detector manufactured by the Makeevka Safety Measures Institute is in use.

The output is 600 tons daily, the productivity of workers being 0.65 ton per man per day. 16-17% of the workers are female. An underground worker gets a minimum of 1,500 Roubles per month, and a surface worker 600-1,000 Roubles per month, wages being on piece work or progressive work.

Coal is washed and dressed by the UMK combined and pneumatic separation process. The grades are (1) greater than 75 mm (by hand picking), (2) 20-75 mm (by UMK), and (3) 4-20 mm (by pneumatic separation). The fines up to 4 mm are not treated. The coal costs are as follows :—

Designed cost	...	Roubles 137 per ton
Actual cost	...	„ 140 „
Pit-head cost	...	„ 130 „
Treatment cost	...	„ 10 „
Selling price	...	„ 180 „

Cheluskuitzy Coal Mine No. 1 (Donetz)

Located about 20 kilometers from Stalino, this mine is worked by the Stalin Vugol Trust and employs 2,800 workers. The coal seams worked dip 10°-20° north. Only 2 seams, L-4 and K-8, 1.5 and 1.1 meters thick, respectively, are mined. The coal formation is covered by 30-meter thick Quaternary formation. The coal contains 18% ash 8-9% moisture, 3-4% S, and its calorific value is 7,800.

Coal mining is done by electrically driven Donetz No. 1 cutter-loaders, using advancing longwall mining method. The cutter-loaders load on to chain conveyers directly into one ton mine cars hauled by an electric locomotive. Coal is hoisted to the surface by six-ton skips. Water is sprayed as a result of fine coal dust.

The daily output is 3,000 tons, the cost of production and washing working at 76 Roubles per ton ; washed coal is sold at 120 Roubles a ton. The washed coal is graded as follows :—

Greater than 13 mm	...	47%
1 mm to 13 mm	...	42%
Fine to 1 mm	...	3%
Dust waste	...	8%

Bogsolovsk Lignite Mine

Located near Karpinsi and worked under the Vahrushervugol Trust, this open-cast for lignite was first opened in 1849. The presence of lignite below 4-6 meters was

proved in 1910, and in 1911 the mine was worked by a French Company. Deep bore holes undertaken in 1930 proved the following sequence :—
(1) 4-12 meters of Quaternary deposits, (2) 350 meters of Mesozoic deposits, and (3) Palaeozoic deposits at base. Lignite occurs in Upper Mesozoics.

The area is highly folded and faulted. The lignite deposit is an unsymmetrical syncline striking north-south. The western wing dips 5°-15° and the eastern wing dips 80°. The total reserve of lignite is of the order of 150 million tons. There are 23 seams totalling 9.5 meters in suite A (uppermost), suite B has 11 seams with a total thickness of 6.5 meters, and suite C a total thickness of 8 meters.

Coal has the following composition :—70% carbon, 4.5% hydrogen, 1.7% nitrogen and 23.8% oxygen. Analyses :—6-23% moisture, 31-68% volatile, 6-43% ash, and trace to 0.5% sulphur. The calorific value is 6,000.

There are seven benches, the height being 12-14 meters at the top and 20-35 meters at the bottom. The benches are 50-70 meters wide.

An electric shovel (SZ-3) built by the Ural Heavy Machinery Building Plant, with a capacity of 4,000 tons daily is the most important equipment. In addition, there are a large electric shovel (EG-2) and a largest electric shovel (3GL-15) weighing 1,200 tons and capable of moving 15,000 cubic meters daily. A belt conveyer (RT-60) hauls the coal to the upper levels

The opencast produces about 25,000 tons of lignite daily. The productivity of workers is 4.7 tons per man per day. The cost works at 21 Roubles at the pit-head. Coal lumps larger than 200 mm. are used for steam raising in locomotives and less than 200 in power stations.

Coal Machinery Plant & Research Institutes

(1) **Gorlovka Machinery Building Plant.**—The plant was originally founded in 1895 by a Belgian Company. Located in the Donetz basin, and under the Ministry of Coal, this factory manufactures large machines, mine ventilators, compressors, centrifugal pumps, excavators and coal cutting Combines (cutter-loaders, etc). In World War II the plant was destroyed.

The six departments of the factory are : Forging, Transportation, Construction, Mechanical Assembly, Small machines and Metal structures. Out of 5,600 workers, 1,700 are women, the average wage being 800 Roubles per month. Wages are based on piece work and progressive bonus system.

(2) **All Union Scientific Coal Research Institute.**— Controlled by the Ministry of Coal, this is one amongst 12 similar research institutes in the U.S.S.R., and employs about 2,500 persons At present 69 research projects are being conducted. The institute is situated in Moscow and has six divisions and 26 laboratories for mining methods,

mechanization of mining and transportation, automatic communications and lighting, geology, opencast mining, boring and explosives, chemistry and physics etc. The Institute has to date spent about 120 million Roubles.

(3) **Makeevka Scientific Research Institute.**—Established in 1927, it was destroyed in World War II. This concerns primarily with safety measures in coal mines and has 600 persons on the staff, 272 being Scientific Workers. The annual budget of the institute is 12 million Roubles. There are 13 experimental stations located in several mining centres in the Donetz basin, in addition to 10 independent laboratories.

Baku Oilfield

The annual output of oil in the Soviet Union in recent years has been of the order of 70 million tons. A hurried visit was paid to the famous Baku oilfield in the immediate vicinity of which there are thousands of oil wells.

An area of 11,000 square kilometers was prospected by the Geological Society of Azerbaijan by 1920. This was followed by mapping on a scale of 1:200,000 and intensive prospecting by drilling and then mapping on scales of 1:20,000, 1:10,000 and 1:5,000. Great progress has been made in recent years by employing modern geophysical methods of prospecting e.g., magnetic, electrical resistivity, gravimetric and seismic, followed by drilling.

The main oil bearing horizons are Pliocene, Oligocene and Miocene, the productive thickness of the beds being 2,400 meters. The deepest borehole is 4,872 meters. Oil is won by turbine drills, and the drilling machines employed are of types UMIMETS, YPB 411 and B-3.

Off-shore drilling for oil in the shallow Caspian Sea began since World War II, and an inspection of the sea oil wells gives the impression that the Soviet experts are capable of making competent planning and geological diagnosis A large sum of money has been spent in constructing sea jetties, altogether 40 kilometers in length, for providing transport of heavy trucks, cars, caterpillar trucks, etc., across the Caspian Sea Specially purified water is pumped into the sea oil wells for increasing the pressure and yield of oil The gas and oil from individual wells are separated by a special process ; the former is utilized for heating and the latter sent to refineries at Baku in oil tankers

UNITED KINGDOM

Introduction.

The workable coal reserve of Britain is estimated at about 43,000 million tons. In 1954 Britain produced 214 million tons. An annual output of 240 million tons has been set as the target by the National Coal Board.

As a result of nationalization of coal mines, in 1947 the National Coal Board took over the collieries and ancillary undertakings, coke ovens, etc. This has enabled the merging of conflicting interests of the individual firms into one united national concern, for working the country's coal resources on a national basis. Many collieries have been modernized, and it is proposed to augment the deep-mine output by capital investment.

The National Coal Board has nine Divisional Coal Boards, each in charge of one of the main coalfields or groups of coal-fields. Forty-nine areas are included in these nine divisions, each being under an Area General Manager assisted by several experts. The yield from an area varies from half a million to nine million tons annually. The National Coal Board controls about 860 collieries in addition to 500 small mines worked under licence from the Board.

Brookhouse Colliery.

Located 7 miles south-east of Sheffield, in the north Midland coalfield the colliery has 1,960 workers and produces 3,000 tons daily. The coal measures are overlain unconformably by Permo-Triassic formation, 4 miles east of the colliery. The exposed coalfield covers 1,600 square miles and the concealed coalfield 1,400 square miles. The seams in the colliery dip 1 in 12 and are traversed by NW-SE normal faults. The coal measures have a downthrow of some 600 feet as a result of the major faults. The workable seams are Flockton seam (3'-3'6'), Parkgate seam (3'6"-5'), Thorncliff seam (5') and Silkstone seam (3'-4'). The coal is used for coking, gas producing, locomotives and domestic purposes

There are two shafts about three-fourths of a mile apart. The downcast shaft is 420 yards deep and is the main coal winding shaft and for raising or lowering of persons. It is provided with an electrical winder having Ward-Leonard system of control. The upcast shaft is provided with a double inlet sirocco fan which produces 200,000 cu ft. of air per minute at 3'5" W.G.

The electricity for the colliery is served from the mains of the Yorkshire Electricity Board The colliery has carpentry, and electric motor and switch repairing, welding, blacksmith and fitting shops. Other ancillaries include a self-service lamp room, a time centre to register the attendance of workers, a personnel training and welfare office, a pit-head bath, and a pit-head hospital to render preliminary treatment.

The mining consists of longwall advancing method and strip packing of goaf. Coal getting at the face is partly by power loaders and partly by machine cut coal hand fitted with face conveyers. The machines at coal face include four Meco-Moore cutter-loaders, two Joy-Sullivan Gloster getter (small cutter-loaders), three A.B. Arc shearing type coal cutters and face belt conveyers. Coal from all seams is brought to a common pit bottom via cross measure drifts, there being altogether 7 tub loading points in the pit. The winding cages are double decked tandem type with provision to get 75 coal windings per hour.

The washing plant a Baum type, can wash coal from 4" to 0", and has a 250-ton per hour capacity.

Astley Opencast

The property has 138 acres and there are three quarry sites for working coal Two seams, 2'6' and 1'6" thick, with an 18-inch parting of shale, are worked. The ratio of overburden to coal at the working face is 11:1, the seam dipping at 1 in 15

The total overburden is calculated at 12,400,000 cubic yards, and the total recoverable coal at 744,000 tons About 100,000 cubic yards of overburden is being stripped every week, recovering 1,000 tons of coal daily. The overburden is removed in 2 shifts and the coal is recovered in one day shift. The main equipments are as follows :—

(1) One 4 cu-yd. drag line (R B. type), diesel driven and fitted with 135' boom ; capacity 23 to 250 cu yds per hour.

(2) Two 4 cu-yd. electrically driven drag line ; capacity 270 cu. yds per hour

(3) One 6 cu-yd. electrically driven/walking drag line; capacity 320 cu. yds. per hour.

(4) Four Bulldozers.

(5) Two American earth-removing plant-D. W. 21, capable of removing 25 cu. yds. per trip.

(6) Four Diesel-driven shovels for extraction of coal with 3/4 cu. yd. bucket.

(7) Eighteen self-tipping motor trucks (8 tons) for transporting coal.

(8) Six tractors and scrapers for reclamation of ground.

Three faces were being worked, the face being 800 ft. long and 40 ft. wide, working in two benches at one time. Coal is hauled to the screening plant located elsewhere by self-tipping motor trucks. The shale parting is scraped by Bulldozers. About 80,000 gallons of water is pumped per hour, and there are 15 pumps to cope with emergencies. Blasting is not required for stripping the overburden.

Underground Gasification of Coal. Newman Spinney

The main object of underground gasification of coal is to use unmineable coal seams for the generation of energy, either as a combustible gas or as sensible heat or both. This method reduces or altogether dispenses with hazards of underground mining, and creates very little surface subsidence as compared to usual mining.

Coal seams at shallow depth, slightly faulted, little moist, and containing high percentage of volatiles, are said to be ideal for underground gasification. The tightness of a working place, avoiding highly disturbed areas, is considered essential. The calorific value of the collected gas is lower than gas from conventional gas works.

The gasification trials at Newman Spinney near Chesterfield, carried out by the Ministry of Fuel, in conjunction with the National Coal Board, were successful, but further tests are being carried out with a view to evolving a method of continuous supply of gas at a very low cost. The following methods were undertaken :—

(a) High pressure air is forced, from the bottom of one bore hole into the coal through the seam and up another bore hole to the surface some distance away, and a passage is burnt through the coal seam which can be gasified.

(b) A heavy electric current is passed from electrode to electrode in a coal seam, as a result of which the coal between the electrodes is converted into coke, which is fissured. This enables air to be passed through the hot coke, which is then converted into gas.

(c) Access to the coal is obtained by sinking shafts and driving galleries along the seam. Bore holes, 100-200 yards long, are driven at the coal face in these galleries. These bore holes are ignited and supplied with air and the resulting gas is brought to the surface.

FRANCE

Introduction

In 1955 the total coal production in France was expected to be 70 million tons, 53% from Nord and Pas-de-Calais coalfield, 20% from Lorraine coalfield, and rest from other coalfields.

The coal reserve in Nord and Pas-de-Calais coalfield is 4,000 million tons, the daily output being 10,000 tons of bituminous coal, equivalent to half of the French output. There are 100 seams, 0.8 to 4 meters thick. The coal is coking, but those with 18-26% volatiles are used for metallurgical purpose.

The Lorraine coalfield has 100 coal seams with an average thickness of 1.75 meters. Coal is high volatile, poor coking quality. The reserve assessed at 5,000 million tons, the daily output being 43,000 tons, i.e., 20% of the total French output.

The French coal mines were nationalized in 1946. The Charbonnage de France was set up recently for planning of coal mines, production, selling of coal, etc.

Coal is washed at colliery washeries or central washeries. The rejection from the washeries amounts to 27% of the mine output and is used in power plants, The run-of-mine coal has 22-35% ash, and metallurgical coal should contain less than 8% ash. The washeries include Pneumatic tables, Plunger Jigs, Baum jigs and heavy media apparatus.

Marlebach Coal Mine (Lorraine)

The seams are 3-5 meters thick and highly inclined, the formation being unconformably overlain by 200 feet thick Tertiary limestone and marl. The 702-meter. shaft which was inspected is sunk through Tertiary formation and Carboniferous rocks, and has a skip winding arrangement, the capacity of the skip being 12 tons

Large scale horizon mining method is employed, the goaf being fully stowed with limestone and marl. The approach to a coal face which advances upwards is through a vertical winze. The working face is 4-6 meters high and is 4-5 meters wide (i.e., equal to the thickness of the seam). Extensive timbering supports both foot-wall and hanging-wall. Coal from face is conveyed to the winzes by small shaker conveyers, and is dropped on to 120-cm. wide conveyer belts for discharging into the 700-ton pit bottom bunker.

900 men work at the surface and 4,100 underground. The number of working faces is 400, each face being driven to a length of 200 meters at 200 meters spart. The daily output is 12,000 tons. The pit-top raising cost is 1,500 Francs per ton. Transport of materials and waste underground is done by battery locomotives, the total installed capacity of the electric machines being 79,000 KW. Electric drills are employed for shot-holes.

Cuvelette Coal Mine (Lorraine)

The area of the mining leasehold is 4 square kilometers. There are three groups of coal, namely, upper, middle and lower, the upper and middle groups being flame coal and the lower group coking coal. The seams are 1-1.4 meters thick and dip almost vertically although dip is gentle to the western part. The reserve upto 600-meter depth is assessed at 5 million tons but further down the deposits are not proved so far.

The two shafts are 700 meters deep ; one is the upcast and the other downcast. The main levels are driven at 100-meter intervals in hard rocks in the upper and the lower layers of the seams. The cross-cuts connect the levels at 300-meter intervals. The 600-meter level is the main haulage level, and the 500-meter level serves as an exhaust airway. The number of working coal faces is 130. Hydraulic packing system is employed for stowing.

No. 1 shaft equipped with a 8,000 H. P. Koepe winding machine is meant for raising coal. No 2 shaft with a 2,400 H.P. drum winding machine is used for men, coal and materials. Diesel locomotives and steel mine tubs are used for main level haulage. Mine tubs and belt conveyers are used for hauling coal and materials on the cross-cuts. Transport of coal from working face to the cross-cuts is done by shaker conveyers.

Out of 1,500 workers, 1,200 work underground, the productivity for total workers being 2 2 tons per man per day. Pit-head cost of coal is 1,900 Francs and selling price is 4,400 Francs.

Bruay No. 6. Colliery (Nord and Pas-de-Calais)

Six coal seams are worked. The average ash of coal is 35% and volatile 35-38%. There are two shafts ; one has skip winding and the other cage winding. The skip hoist can deal with an output of 7,200 tons per day in two shifts. The skip has two decks at its top to lower and raise men and material. The ventilation is done by a propellor fan (141 cu. meter/sec) The heavy medium washery at the mine washes all +10 mm coal to 4.5% ash, the -10mm coal being despatched to a nearby washery for dry beneficiation in a Boitley table type washer.

Henin-Lietard Mine (Nord and Pas-de-Calais)

The mine area is 3 square kilometers. There are six coal seams, 60 cm. to 2.5 meters thick, dipping at 40°-50°. The reserve is assessed at 12 million tons.

The mine has two coal winding shafts. Horizon system of mining is followed. The shafts are sunk through 110-120-meter thick limestone and marl before the coal measures, their present depth being 409 meters. Coal has been worked out in the first horizon at 228-meter level. Exploitation and development are being made in the second horizon (282 meters) and in the third horizon (409 meters). The fourth horizon is contemplated at 533-meter level.

Cross measure drifts have been driven at different directions at the pit level to get coal from the various seams. Longwall advance system is followed for winning coal and the development of galleries for this purposes is done by shortwall coal cutters and 600 litre tubs. The Gate conveyers (belt conveyers) installed in each of the seams deliver the coal into the winzes through special chutes and sometimes through retarding conveyers. The winzes are 120-125 meters deep and 4 meters in diameter. There are 4 winzes at the pit level connected with the different seams.

Seventeen longwall faces, 150-200 meters long, were being worked, the total daily output being 3,500 tons. Coal raising cost is 4,000 Francs, of which 55 Francs is the amount of compensation for surface damage due to subsidence.

Coke Plants & Power Stations.

(1) **Carling Coke and By-product Plant.**—Located in Lorraine basin, the plant uses a blend of 80% Lorraine coal and 28% Ruhr coal from West Germany. The charge in the oven contains 29-30% volatile and the coke 1-2% volatile. There are altogether 160 ovens in seven batteries. One ton of coke yields 750 kgms. of coke of different size for use in blast furnace and domestic purpose. The temperature in the centre of the oven is 1,350°C, and the coking time is 19 hours. The coke breeze (below 20 mm.) is blended with fresh coal for manufacturing fresh coke. The by-products are tar, ammonia, benzol and naptha, the residual gases going to the neighbouring synthetic plant for the manufacture of 200 tons of ammonium nitrate daily.

(2) **Violaines Power Station.**—Located in Nord and Pás-de Calais coalfield, this power station will have 100,000 KW capacity, and when completed, will have cost a capital expenditure of six billion Francs. Pulverized blended coal (5,000 calories)

containing up to 45% ash and 20-25% volatile will be used in the boiler. 1,000 workers were present during the visit but only 100 men will be employed when power house will be in operation.

(3) **Choques Thermal Power Station.**- It is linked to the National Electric grid. The boiler is designed to use pulverized coal, the blend containing 3% moisture, 29.9% ash and 28.5% volatile, with a calorific value of 5,715 calories, Coal containing up to 40-45% ash can be used in the boiler.

WEST GERMANY

Introduction.

West Germany produces annually about 120 million tons of coal and 88 million tons of lignite. Largely worked by private companies, several large mines are operated by the State like company managed undertakings to overcome the difficulties of State management. Several adjacent mines are integrated into a single unit, thus facilitating large scale mechanization in large mines and closing down uneconomic holdings. Extensive drilling programme is in progress for all future development and planning.

Adaptation of the working methods for natural conditions, use of proper coal face machinery, an efficient haulage system, etc., have contributed to the large outputs from mines. The main haulage is by locomotives on level roads, driven through the strata and connected with the seams by cross measure drifts and by staple shafts.

The system of free training centres attached to the mines for freshers and junior technicians has been responsible for greater output and lesser breakdown of machinery. The miners are given cheap accommodation, free coal and medical aid. Most work is done on piece rates fixed between employers and miners. A machine face worker gets 25-30 D. M. daily.

It is not economical to transport lignite to a great distance and thus the large thermal power stations installed near the mines use lignite as a boiler fuel producing cheap electricity. Nearly 22 million kilowatts a year is generated in West Germany using lignite. Besides, lignite is also used for the manufacture of briquette near the mines for domestic and industrial use, as well as a raw material for chemical industries. The 100 million ton target for lignite output by 1960 is needed for the increasing demand of the power stations.

Friedrich Heinrich Colliery

An amalgamation of various concessions, it is one of the most important mines in the Ruhr Valley coalfield. Out of a total leasehold of 34.65 square miles, 11.07 square miles of the area is being worked. The 12 workable seams are 0 8 meter to 2 30 meters thick and dip at 10°. As a result of dirt partings the entire run-of-mine output needs washing. The daily output is 10,000 tons giving 7,200 tons on washing.

Horizon system of mining with longwall advancing faces in the individual horizons is followed the total length of the coal cutting face being 239 meters. Two shafts are mainly for winding coal by skip and cage respectively, the third shaft being only for men and materials. The 600-meter horizon is the main working horizon in one of the coal raising pits and the 300-meter horizon in the other.

Coal is lowered from the different working seams to the winding pit level by spiral chutes through "blind" shafts Coal is cut and loaded by coal ploughs and double chain conveyers in the fully mechanized sections, whereas coal cutting machines and pneumatic picks are used in the partly mechanized sections, and scraper chain face conveyers deliver the coal to the gate belt conveyers. Solid stowing and strip packing are done in the goaves below residential areas.

Two Capell fans with an individual capacity of 14,000 cubic meters per minute and two Hohenzollern fans with a capacity of 6,000 cubic meters per minute are used for underground ventilation.

The total number of workers in surface, underground and auxiliary plants is 6,653. The total output per manshift for underground and surface workers is 1,596 tons.

Roddergrube Quarry

This mining area in the Lower Rhine Valley is 35 kilometers by 2.5-8 kilometers. Tertiary brown coal (lignite) here has a maximum thickness of 100 meters, and the overburden is about 290 meters. The laying of the mine was based after detailed geological mapping and sinking of several thousand bore holes, as the formation is highly disturbed, the thickness of the seam changing within short distances. The total daily output from four opencasts is 108,000 tons.

The crude lignite has 25-32% carbon, 1.9-2% hydrogen, 9-12% oxygen, 0.2-0.3% nitrogen, 0.2-0.3% sulphur, 50-60% water and 1.8-3.5% ash. It has a calorific value of 1,800-2,700 kilo calories.

The overburden of sand and alluvium is 55 meters thick, and coal is 15-20 meters thick in No. 1 mine. The quarry is 2 kilometers long. Five continuous bucket dredgers remove the overburden in two benches of height 35 meters and 20 meters. Three are upward cutting for stripping of overburden from the upper bench and two are downward cutting for removal of overburden from the lower bench. Both sets move along the rail line and deliver the material into 60-ton side dumping wagons on the rail line laid on the second bench for drawing by electro-locomotives to the dumping ground. A dredger can strip 12,000 tons in 24 hours, each of the bucket having a capacity of 600 litres. The dredged earth is dumped in excavated areas.

Two continuous bucket dredgers cut the top 12 meters of coal and deliver into 85-cu. meter wagons. Two shovel excavators remove the bottom 3-4 meters of coal. 180 workers work in this section, the output per manshift being 210 tons.

Fortuna-Nord Opencast

Located north-west of Roddergrube quarry, this lignite opencast in the Lower Rhine Valley works a 80-90 meter thick seam which to the north splits up into two seams, 30 and 60 meters thick.

The overburden is stripped by bucket dredgers on Caterpillar trucks, the buckets having a capacity of 1,000 litres. There are also bucket wheel dredgers, one for coal and another for overburden, the capacity of the buckets being 850 litres. The dredged earth and coal are hauled by 80-cu. meter capacity wagons drawn by electric locomotives.

Rite and Schweitzer submersible pumps in boreholes in solid ground near the working area are employed for depressing the ground water table down to the bottom of the opencast. With a view to draining out as much water from lignite bed as possible, advance rise galleries are driven through the lignite seam, the water being pumped out from the working face by electric pumps.

Frimmersdorf Opencast.

Located further west of Fortuna-Nord quarry, this opencast for lignite will attain a total depth of 180 meters. The two seams are 15-20 meters and 10-15 meters thick with a 10-20 meter thick parting of sand bed. The system of stripping the overburden is same as in case of Fortuna-Nord opencast A very large bucket wheel dredger is installed. It weighs, 5,000 metric tons and has a capacity of 5,700 cubic meters per hour, It is priced at 18 million D.M.

Mining Machinery Plants, Research Institutes, etc.

(1) **Gutehoffnungshutte Sterkrade A.G.**—This Mining Machinery and Equipment concern manufactures all mining equipment for mining industry, advises on construction of new collieries. and has a well equipped research section.

(2) **Eickhoff Maschinen-fabrik und Eisengiessere m. b. h.**—This engineering works and iron foundry concern at Bochum, in co-ordination with the mining industry, designs and manufactures all types of coal cutter-loaders, loading machinery and different types of conveyers. There are altogether 1,400 workers.

(3) **Shaft Building Co. Ltd.**—Reputed as one of the most important concerns of its kind, this firm at Essen specializes in shaft building, enlarging and sealing of shafts, etc., and has a well equipped research laboratory.

(4) **Fried, Krupp Machine and Steel Construction.**—Situated at Rheinhausen, Ruhr, this concern is reputed to be the largest steel mill in Europe having nine blast furnaces with a capacity of 700 tons a day, six Bessemer mixers, a few open-hearthers, and various auxiliary plants, including a test plant of the Krupp Renn Process.

There are 12,000 persons in the concern. The monthly output is 90,000 tons of Bessemer steel and 60,000 tons of open-hearth steel.

(5) **Dr. C. Otto. & Co.**—This firm at Bochum-Daldhausen specializes in the construction of plants for the processing of coal, oil and natural gas, and manufactures refractory bricks for various industries. The firm has excellent coal research laboratories and advises on the production of metallurgical coke from weakly or non-coking coals by the adoption of special measures, e g., an appropriate pre-treatment of coal, blending of coals, adaptation of the coking conditions, etc. For preliminary testing 30 kgms. of coal sample in air tight boxes is desired.

EAST GERMANY

Introduction

Brown coal is the backbone of the whole economy in East Germany, there being only a few bituminous coal mines. In 1954 the State's total output of brown coal was 180 million tons, most of which is mechanically refined. Practically the entire coal output is by opencast.

Brown coal is the basic material for the recovery of tar, oils, petrols, paraffin, low and high temperature coke, gas, sulphur, phenols, etc. It is also used for briquetting and for generation of electricity.

The overburden comprises sand and earth, and the ground water level in some quarries needs to be depressed by installing filtering wells and submersible pumps. As a result, the use of continuous bucket dredgers, both of the chain and wheel type, has been very efficacious to strip and win the lignite

Drag lines are also advantageously used for dumping of soil. Overburden bridges, with spans from 200-600 meters, are installed to overbridge the distance between coal service and dump, to dump the overburden direct into the exploited pit upon the floor of the lignite, through belt haulage.

The seam characteristics of India are different and adöption of these bridges may not be feasible. It would be easier to transport the overburden round the mine to the dumping site by belts or in wagons drawn by locomotives.

Greifenhain Opencast

Located 17 kilometers north-east of Senftenberg, the mine area covers some 1,700 hectares. The seam (Tertiary lignite) has a thickness of 10 meters and occurs below 20-50 meter thick overburden of sand with clay partings. The yield of water at the working face is 40 cubic meters per minute. Top section is high in ash and used for power house boilers, whereas the bottom section with 7% ash and 12% tar is used for coke.

A crawling, swivelling type continuous bucket chain excavator strips the overburden and discharges into the railway wagons driven by electric locomotives. The excavated material is dumped 6 kilometers away into an old coal pit, the dumping ground being made level by a giant earth leveller and reclaimed for cultivation.

Two shovels of 900-cu. meter and 300-cu. meter capacity cut and load coal into 60-cu. meter railway wagons. Coal is worked in 2 benches, the length of the face being 1,600 meters

Sub-soil water is present in overburden and coal seam. Small headings are driven in the working face through the seam. These galleries are connected by the vertical drill holes from the overburden, and the water drawn to the central pumping station in the quarry.

Friedenswacht Opencast

Located in Lauchhammer, this quarry works a 10-12 meter thick lignite having a 30-35 meter thick overburden. The amount of overburden stripped daily is 60,000 cubic meters, and daily output of coal is 20,000 tons.

The overburden is worked in two benches, using a bucket wheel dredger on caterpillar track at the upper bench, and two continuous bucket dredgers at the lower bench. They deliver the material to the belt conveyer of the 246-meter long transport bridge moving on rails, a recent innovation, which transports the excavated earth to excavated areas, thus dispensing with wagon transport of the spoils. 600-meter long bridges are in operation elsewhere in East Germany. They are useful only in case of horizontal, continuous seams. Their weight varies from 300 to 9,500 tons.

Three dredgers of the continuous bucket type extract the coal in two benches, and discharge it into self-emptying 50-cu. meter capacity wagons. The top section coal (10% ash) is used in boilers for power stations and the bottom section (2-3% ash) is briquetted.

Coke & Briquetting Plants

(1) **Matyas Rakosy Coke Plant** —Located in Lauchhammer area, this plant manufactures metallurgical coke from brown coal and is claimed to be only of its kind in the world employing 2,000 persons The lignite contains 50-60% moisture, 2.5-3% ash, 2.5-4% tar and 0.3-0.4% sulphur. The annual yield of coke with 12 units of oven is 540,000 tons. With the setting up of another 12 units, the output will be 1 000,000 tons. Briquettes from the neighbouring plant in Friedenswacht, containing 12-15% moisture, 5-6% ash and 7-8% tar, are used. The by-products are tar (3.3%), light oil (2.5%) and phenol (0.24%). The method of producing brown coal high temperature coke was developed by Prof. Dr. Rammer and Dr. Bilkenroth of the Frieberg Mining Academy, who undertake testing of brown coal in their laboratory A sample weighing 500 kgms, is required ; it has to be drawn and sent according to their instructions.

(2) **Friedenswacht Briquetting Plant**—Located six kilometers from the Friedenswacht brown coal mine, the plant has three units. The unit put in operation in 1954 was visited. The coal delivered at the plant contains 58% water. No binders are used, the operation of binderless briquetting plants being determined by factors such as peculiarities of the coal, moisture content in the dried coal, etc.

(3) **Low Temperature Distillation and Gasification Plant at Kombinat "Otto Grotewohl", Bohlen**—The feed into the retort comprises a mixture of 70% briquette (15% H_2O), 20% briquette rubble (15% H_2O), and 10% preliminary dried coal (30% H_2O). The yield of gas is 980 cu. meters per ton of moisture free coal, from which tar, middle oil and benzol are recovered before delivering it to the gas grid. Sulphur is recovered from the gas by passing it through ferric hydroxide. The gas plant has a liquid oxygen plant for gasification of brown coal.

VI. MINING AND GEOLOGICAL EDUCATION

U. S. S. R.

In the Soviet Union the training of Geologists, Mining Engineers and Junior Mining Technicians is invariably linked with the mineral development and industrialization of the country. The principal authority to set the target of the number of students to be trained as Geologists and Mining Engineers annually is the Ministry of Higher Education. For this purpose this authority consult the Ministry of Geology & Conservation of Mineral Resources and other Ministries concerned, regarding their requirements, and thus guarantees employment to all students after graduation. This body also works out the curriculum, issues text books and conducts examinations in close collaboration with the relevant Ministries.

The various universities, technical institutes and middle technical schools called technicums offer facilities for the training of Geologists. The emphasis of university education is on academic research whereas technical institutes are particularly inclined towards the practical aspects in the field of geology and mining. The training of Mining Engineers and Junior Mining Technicians is done through the medium of several technicums and institutes.

Specialized training in geology and mining is done through 41 institutes of higher learning. In addition there are 30 universities with departments of geology and 5 institutes for specialized training in the oil industry.

The technicums are under the control of the Ministry of Geology and Conservation of Mineral Resources and other Ministries concerned The present number of geological prospecting technicums attached to the Ministry of Geology is five, but another five are being set up.

The total outturn of Geologists graduating annually from institutes and universities is of the order of 5,000. The total strength of students at the various technicums attached to the Ministry of Geology is about 6,000 of which 1,500 to 1,800 graduate annually. The number of students at technicums of other Ministries is about 14,000 out of which about 5,000 graduate annually.

In the Soviet Union subsistence allowances are paid to the trainees according to the following schedule :—

	Institutes of Higher Studies for Geology & Mining Engineering Roubles/Month	**Middle Technical Schools or Technicums Roubles/Month**
1st Year	395	285
2nd Year	420	315
3rd Year	450	360
4th Year	450	390
5th Year	480	—

An additional 25% subsistence allowance is given to students securing brilliant marks in all subjects. Usually students are charged annual tuition fees at the rate of 300-400 Roubles in institutes and universities and 150-200 Roubles in technicums. The State's annual contribution for training a student is 13,000 Roubles at a university or institute or 8, 000 Roubles at a technicum. The student's contribution for training is generally 2.3% of the total cost of training.

The period of training in an university or institute is five years. Generally 2½ to 4 years are needed in technicums but this would depend on the previous general education of the student. For the purpose of lectures, Junior Geologists and Mining Technicians are generally taught in groups of 30, whereas for laboratory and practical work 10 are grouped together. Great stress is laid on practical and laboratory work. The time allocation for various aspects of the training in a year is as follows :-

	Institutes		**Technicums**	
	Number of hours.	%	Number of hours.	%
I. **Theory**				
1) General educational and general technical subjects	864	9.6	1,850	24.3
2) Special subjects	1,128	12.6	1,155	15.2
II. **Laboratory and Practical work**				
1) General educational and general technical subjects.	1,238	13.8	245	5.6
2) Special subjects	1,210	13.5	494	6.5
III. **Practical training**	1,728	19.4	1,776	23.4
IV. **Preparing and defending of thesis**	612	6.9	324	4.2
V. **Examination**	1,080	12.1	504	6.6
VI. **Vacation**	1,080	12.1	1,080	14.2
Total ...	8,940	100	7,428	100

A student's work in practical training is guided by an Engineer, so that he becomes conversant, under actual working conditions, with the modern practice of mining with the aid of up-to-date equipment and machinery. He works in the beginning as an ordinary unskilled labourer, then gradually as skilled worker, collector, foreman or junior specialist. He is entitled to the pay for the posts he holds and also to the State subsistence allowance. A junior technician working underground gets 600 to 700 Roubles per month, and a graduate student, 1,100 to 1,500 Roubles per month.

In the mining regions the evening classes of the "correspondence" departments of the institutes and technicums are becoming popular amongst those who are unable to attend day courses. Those willing to join such departments are released from any assignment in the evening, and are given facilities such as leave of 30 days to appear for examinations on full pay, 2-4 months' leave for preparation for examinations, etc. Both day and evening students get one month's leave with stipend on graduating from any technicum.

There are no evening courses for geological prospecting but they are covered in the "correspondence" departments in 3 technicums of the Ministry of Geology, 3 technicums in other Ministries and 50 institutes and universities.

The Study Group visited the following higher training organizations in the U.S.S.R. : -

(1) **All-Union Research Institute in Geology in Leningrad.**—Originally established in 1882 and subsequently re-organised in 1939, the institute possesses excellent and up-to-date laboratories where several top-ranking Geologists of the Soviet Union carry out many geological investigations which are not undertaken elsewhere in the country. This type of institute is one of the best for advanced training in geology from the ECAFE region.

Headed by a Director, under a Board of Directors, the institute has a complement of 1,000 personnel, inclusive of 2 Members of the Academy of Sciences of the U.S.S.R., 3 Corresponding Members, 41 Doctors of Science, 182 Candidates of Science and 250 Scientific Workers with higher education. Generally 700-800 Geologists work in the field annually, but no actual prospecting is undertaken. The annual and five year plans of the institute have to be approved by the Ministry of Geology.

There is a Special Commission to effect co-ordination with similar organisations, in addition to a Scientific Council consisting of a consulting body of experts in various fields. The laboratories comprise thermal, electro-magnetic, electron microscope, chemical and hydro-chemical laboratories and a laboratory for determination of absolute age of rocks by potassium and argon contents. The library has some 500,000 volumes of books, and the Museum has one million specimens and 400,000 rock sections. The most important functions of the institute are as follows :—

(1) Guidance in preparing geological maps of the U.S.S R , and preparation and printing of large scale geological and special maps of the U.S.S.R.

(2) Study of geological structure and formation of ore deposits.
(3) Research work on petrography, stratigraphy, palaeontology, etc.
(4) Working out improved methods of geological survey and search and prospecting of minerals.
(5) Theoretical problems in geology.
(6) Training of specialists.
(7) Publication of monographs, reference books and instructive brochures.

The division of generalized geological maps has completed a geological map of the U.S.S.R., on a scale of 1:5,000,000 The geological map on a scale of 1:2,500,000 is likely to be out soon and the map on a scale of 1:1,000,000 is under preparation. The institute also performs special lithological maps, tectonic maps, structural maps, hydrochemical maps, metallo-genetic maps, palaeo-geographical maps, etc.

There are six regional divisions for making regional geological maps and studying mineral distribution of the respective territories. In addition, there are subject divisions, e,g., petrology, geomorphology, hydro-geology, stratigraphy, etc.

The students from different technicums or institutes work as Junior Assistants to obtain experience, and after graduation, work as Junior Scientific Workers while preparing for the degree of Candidate or Doctor of Science. During the visit, 70 post-graduate students, mostly graduates from other institutes, were being trained in the institute.

(2) **The Academy of Sciences of the Uzbek Republic and its Institute of Geology** :—In the whole Soviet Union twelve Republics have their Academy of Sciences. The other four republics have no Academy of Sciences of their own, and are affiliated to the All-Union Academy of Sciences in Moscow. To co-ordinate the work of all the Academies of Sciences, there is a Council of Co-ordination in Moscow.

The Academy of Sciences of the Uzbek Republic, which the Group visited, comprises four divisions, i.e., (1) Physics and Mathematics, (2) Engineering, Geological and Chemical Sciences, (3) Biological and Agricultural Sciences, and (4) Humanitarian Sciences. The Division of Engineering, Geological and Chemical Sciences, in which the Group was interested, consists of four Institutes : Geology, Construction, Energy and Chemistry

The Academy of Sciences of the Uzbek Republic deals with (1) general scientific questions, (2) problems of importance to the Rupublic, (3) cultural problems relating to the Rupublic and other countries, (4) training of post-graduate candidates for higher degree, and (5) publication of research works.

The Institute of Geology has 12 laboratories : (1) Palaeontology, Stratigraphy and Regional Geology, (2) Ore-dressing, (3) Engineering Geology, (4) Sedimentary ore deposits, (5) Petrology and Petrography of sedimentary rocks, (6) Oil Geology, (7) Geochemistry, (8) Petrology and Petrography of igneous rocks, (9) Endogenic ore deposits, (10) Spectro-analysis, (11) Mineralogy, and (12) Chemical.

The institute also has facilities for post-graduate students to do advanced research leading to the award of the Candidate of Science degree. Entrance to the post-graduate department of the institute is subject to competitive examination. During the time of the Group's visit there were 27 members working in the post-graduate department The recommendation for the award of a doctorate degree to the Candidates of Science is made by a Special Scientific Council of the Institute, but only a Special Commission in Moscow has the final authority to award the degree.

(3) **Kirov Polytechnical Institute.**—This institute has a faculty of mining and geology in addition to eight more faculties. Specialized training is offered in the following subjects :—

(1) Geology and prospecting for mineral deposits
(2) Hydro and engineering geology
(3) Mine surveying
(4) Exploitation of mineral deposits
(5) Mine construction
(6) Operation of mining enterprises
(7) Mining mechanics

(4) **Sverdlovsk Mining Institute.**—Ranking next in importance to the Leningrad mining institute, this institute is headed by a Director and assisted by a Scientific Board. The six faculties are: Mining, Mining Mechanics, Geological Prospecting, Geophysical Prospecting. Oil and Mining Construction. There are at present 350 Scientific Workers.

Out of 4,000 students, 1,500 specialize in the field of geology. The period of full training course is 4 years and 10 months. The academic year being divided into two terms of 4-5 months. At the final year a student has to submit a thesis for scrutiny by the State Examination Board. The full course covers 251 weeks out of which 30-40 weeks are allotted to practical work and 140 weeks to lectures, the rest of the time being meant for examinations, vacations, etc,

(5) **Moscow State University.**—At present a great stress is laid upon the production of a large number of trained Geologists from the universities in the Soviet Union. The University of Moscow, the oldest in the Soviet Union, recently celebrated its bi-centenary. The recently constructed building, 32 storied in the central part, houses the university, its various faculties, hostels, residential staff quarters, etc., and is the tallest building in Europe.

The university has 12 faculties. Directed by a Dean, and assisted by 17 Professors, the faculty of geology covers geochemistry, geophysics, prospecting for minerals, hydro-geology and engineering geology. The courses followed in the 1st year are same but there are minor differences in the 2nd and 3rd year courses Specialization takes place in the 4th year.

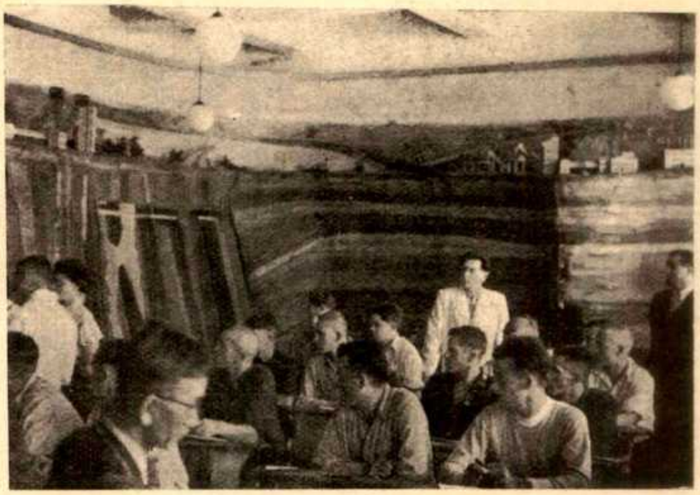

Fig. 1.

Lecture Theatre, Gorlovka Mining Technicum, U.S.S.R.

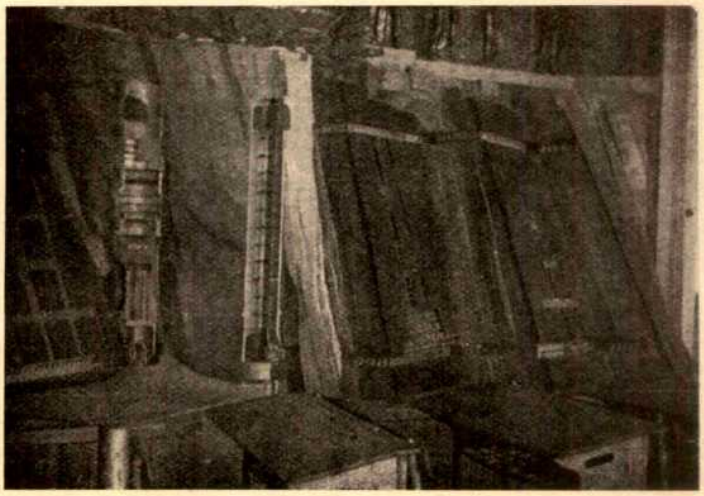

Fig. 2.

Part of Lecture Theatre, Gorlovka Mining Technicum, U.S.S.R.

Fig. 3.
Coal Miners' Sanatorium at Sochi by Black Sea, U S.S.R.

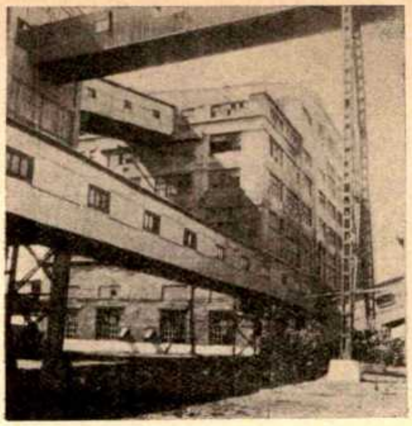

Fig. 4.
Coal Dressing Plant, Donetz Basin, U.S.S R.

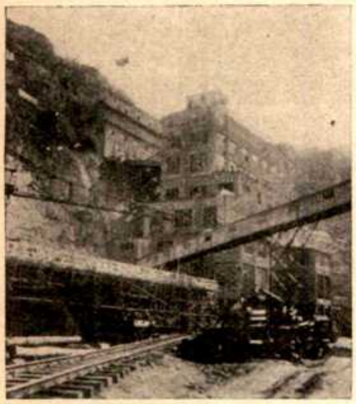

Fig. 5.
Manganese-ore Beneficiation Plant at chiatura.
Caucasus. U.S.S.R.

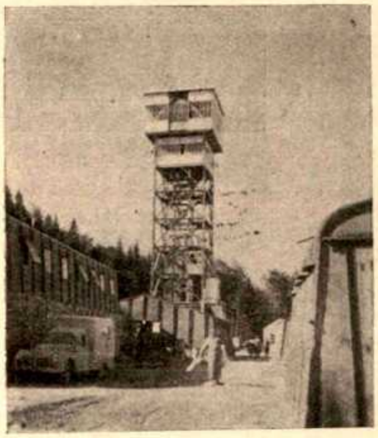

Fig. 6.
Ore Dressing Plant at Lachaux Uranium Mine, France.

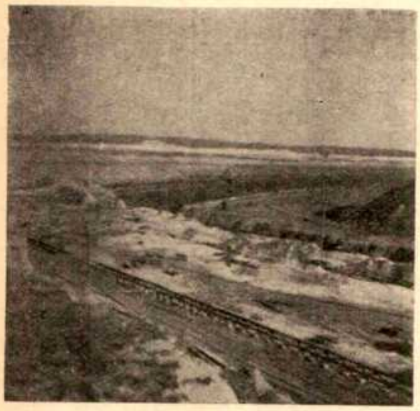

Fig. 7.
Lauchhammer Lignite opencast, East Germany.

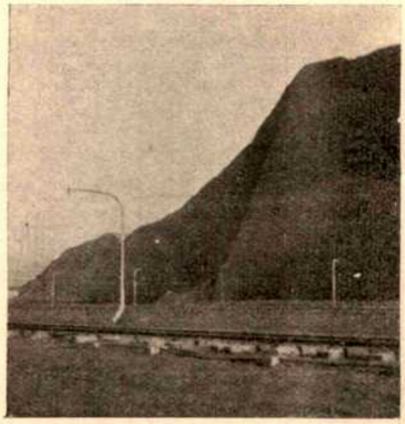

Fig. 8.
A Lignite open cast in the Lower Rhine valley.
West Germany.

State stipends are awarded to 96% of the students, at the rate of 290 Roubles per month for the 1st year to 500 Roubles per month for the 4th year. Students of outstanding merit receive special stipends. The room rent paid by a student amounts to 23 Roubles per month and messing charge is 5-10 Roubles per day. The tuition fee charged to the students is about 400 Roubles annually.

The geology faculty has got rooms in 8 floors and covers some 7,000 square meters of floor space. There are 13 Chairs for Dynamical geology, History of geology, Palaeontology, Geology and geochemistry of oil and gas, Useful minerals, Geophysics, Hydro-geology, Engineering geology, Permofrost (study of frozen ground), Petrography, Mineralogy, Crystallography and Crystal-chemistry, and Geochemistry. The heads of Chairs get 6,000 Roubles per month. In some Chairs there are four to five Professors.

There are altogether 1,200 students in the geology faculty, 40% being girls. In addition, there are some 80 post-graduate students. The period of whole course is 5 years. 50% of students have joined after completing 10 years in primary schools. 10% students, joining the 1st year, originate from geological technicums. In 1955, 225 students were admitted in the geology faculty.

In 1st and 2nd years, general subjects, mathematics, physics and chemistry are taught. In 3rd year mainly geological subjects are taken. Special geological subjects are principally taught in 4th and 5th years. English is compulsory. Apart from oral tests, no written examinations are held in any classes.

The special courses include (1) geological surveying and search for minerals, (2) geology and prospecting for useful minerals, (3) geology and prospecting for oil and gas, (4) geophysical methods of prospecting, (5) geochemistry, and (6) hydro-geology and engineering geology.

There are 30 Doctors of Science amongst the Professors. One-third time is spent on lectures and the rest in laboratory work, practice in field, etc In 1st to 4th years, the total time devoted is 32 hours a week, and in 5th year 24 hours a week. The studies in 1st to 3rd years begin in June-September and in 4th and 5th years in October. The winter vacation is for two weeks.

Hitherto, the theses were defended before the Chairs, but the State Examination Commission nowadays does the evaluation. Post-graduate work for Candidate of Science degree, claimed to be equivalent to doctorate in Germany, France, etc. Doctorate degree is given after Candidate of Science degree, after many years of work, and the thesis is to be approved by the Scientific Council of the Department and then by the Scientific Council of the university.

The Study Group visited the following technicums on geology and mining, representing typical training centres at a junior level :—

(1) **Kiev Geological Prospecting Technicum.**—Established in 1930, the technicum has one Director, 2 Deputy Directors and a total staff of 104. The annual

budget is about 14,000,000 Roubles. The technicum has 22 laboratories and lecture theatres, a library having 60,000 volumes, a conference hall for 600 people and a gymnasium. The total number of day students is 2,650, 30% being girls. There are 300 "correspondence" scholars. About 700-750 students are admitted every year.

Students having completed the 7th grade in primary schools are admitted to the 1st year and their period of study is 3 years 8 months. Students who have completed the 10th grade are taken in the 3rd year, and have to do 2 years 6 months. The age of the students varies from 14 to 30.

The training course is guided by the Ministry of Higher Education and the Ministry of Economic Planning, the emphasis being more on practical work and realistic industrial training in mining or explorations. The principal subjects covered are (1) geology and prospecting for minerals, (2) drilling and prospecting, (3) geophysical prospecting (electrical, seismic, gravimetric and electro-magnetic), and (4) economic planning of prospecting.

The field work of the student is done under the supervision of experienced Geologists attached to the Prospecting Expedition Parties, teachers of the technicum or Mining Engineers from various Combines or Trusts. The period of field work is about one quarter of the whole course. A Board consisting of a State Commissioner, teachers of the technicum and Mining Engineers and Geologists from other institutes, examines the thesis of the students before the final award of diploma Visual aids, maps and illustrations, various mechanical devices, etc., and training in assembling and dismantling machines, repairs, etc., speak of emphasis on the practical aspect of training.

Employment to graduates is offered through a Board (State Commission) consisting of :—

(a) Director of the technicum.
(b) Representatives from the Ministry of Geology.
(c) Representatives from industrial enterprises.
(d) Representatives from the Young Communist League.
(e) Representatives from Trade Unions
(f) Representatives from other public organizations.

Five per cent. of the brilliant graduates are sent to other institutes of higher education. A graduate on employment is entitled to 390 Roubles per month, and is granted free travel, accommodation and medical treatment. A student's family members also get a subsistence allowance of one quarter of that allowed to a student.

(2) **Gorlovka Mining Technicum**—Established in 1876, this technicum has 38 day classes, the total number of students being 1,400. Hostel facilities are available for 800 scholars. There are 19 class rooms. Morning session begins at 7-30 A. M., afternoon session at 1 P. M. and evening session at 6 P. M. The number of girl students is not much, as the technicum is solely devoted to the training of underground mining

technicians. During the visit 40 girl students were on the rolls. The teaching staff consists of 40 teachers and 80 demonstrators and instructors.

The principal laboratories of the technicum are (a) Mining Electricity, (b) Mining Mechanics, (c) Mining Equipment, (d) Ore Transportation, (e) General Mining, and (f) General Electrical Methods.

The emphasis is on the practical side, and laboratories with visual aids, maps and illustration, and all types of possible machinery, reflect the fundamental practical aspect of the training. Practical work in mines takes 25% of the time allotment, and the rest in laboratory practice and lectures.

The subjects include, besides cultural subjects and sports, (a) Higher Mathematics, (b) Technical Drawing, (c) Theoretical Mechanics, (d) Practical Mechanics, (e) Machine Design, (f) Electrical Practice, (g) Mining Machinery, (h) Structure of Metals, (i) General Geology, (j) General Mining, (k) Mine Surveying, (l) Elementary Geodesy, (m) General Mining Equipment, (n) General Mining Mechanics, (o) Transportation of Ore, (p) Electrical Mining Apparatus, (q) Coal Beneficiation, (r) Economic Planning and Work Organization, (s) Preparation of Technical Reports and Calculations, (t) Rules of Technical Operations, (u) Political Economy, (v) One Foreign Language.

Only students who have completed 10 classes in the primary schools are entitled to enter the school. The duration of the course is 2½ years. A student on graduation, on the completion of three years of work in a mine, can join an institute of higher learning.

UNITED KINGDOM

In the United Kingdom, geology and mining are taught in several universities leading to degrees. The Study Group visited the Imperial College of Science & Technology in London and a Mines Mechanization Training Centre in Sheffield.

Imperial College of Science & Technology.—Established in 1907, the Imperial College of Science & Technology is constituted of (1) The Royal College of Science, (2) The Royal School of mines, and (3) The City and Guilds Engineering College. Instruction is given at the highest level and facilities of research are also given. The undergraduate courses of three years at the Royal College of Science and the Royal School of Mines lead to the B.Sc. (Special) degree of the London University and also to A.R.C.S. or A. R. S. M. diploma. The advanced study and research lead to the diploma of D. I. C. and to London university degrees of M.Sc , Ph.D. & D.Sc The Department of Mining has a sub-department of Mineral Dressing. I noticed marked changes in the Imperial College since I was a student here in 1931.

Mines Mechanization Training Centre.—Working under the authority of the National Coal Board, this training centre at Sheffield imparts training to those working in the coal mines as miners and officials, in operation and maintenance of coal mining machineries. Applicants are required to apply either through their colliery manager or any official from the coal industry. The age of candidates should be between 17 and 24. The following courses of training are offered :—

(1) Apprentice fitters and electricians (12-week course each)
(2) Colliery fitters and electricians (4-week course)
(3) Machine operators (2-week course)
(4) Under-officials in charge of mechanized mines (2-week course)
(5) Maintenance men (mechanical & electrical training-26-week course & specialization in mechanical & electrical parts-16-week course)
(6) Directed practical trainees' course in mechanization and mining equipment (3-week course)
(7) University undergraduates' course (one-week course)

Fares to and from the training centre to the trainees' homes are paid. Maintenance allowance is given to the students, and an extra allowance is given for dependents. The wages are fixed on the basis of their daily wages or average weekly earnings. There is provision for medical treatment and social activities. The students are looked after by a welfare officer.

FRANCE

In France the students are trained in universities and 'grandes ecoles". The faculty of natural sciences in the universities include geology, and a geology student usually studies physics, chemistry and mathematics. The various Ministries of the Government are responsible for the setting up of the "grandes ecoles" with a view to obtain trained personnel in various branches of the industry, including specialization in geology. The emphasis in university is on the academic side, whereas "grandes ecoles" tend to have a practical approach.

The principle underlying the training both in universities and "grandes ecoles" is to give a sound theoretical training supplemented by thorough laboratory and field training and mining practice. In France there are 17 science faculties teaching general and advanced geology. In order to have adequate number of Geologists and Mining Engineers for various Government departments and the industry, the various Ministries co-ordinate in a large measure for the outturn of qualified and properly trained personnel.

Both entrants to the universities and "grandes ecoles" are selected by competitive examinations, and should have passed the Baccalaureat, part II, signifying that the students had taken physics, chemistry and applied and pure mathematics. A student in the university is required to pass either the "Certificat Propedeutique des Sciences" (physical chemistry and natural science) or the "Certificat Propedeutique de Mathematiques" (physics and chemistry). For entrance to the geology courses both certificates are considered adequate, and advanced courses in geophysics, prospecting for minerals and water, petrography, stratigraphy, etc., are given in the university.

In some of the "grandes ecoles," e. g., the Polytechnique, the School of Mines and Institut Francais du Petrole, a general course in geology is given in the beginning. The students after graduation are called Engineer Geologists. Further specialized training courses in the field of geophysics, hydraulics, prospecting, etc., are provided in the universities and "grandes ecoles" after graduation.

Foreign students with academic qualification may enter both French universities and "grandes ecoles", on individual merits, subject to the concurrence of the departmental head. Foreigners can also obtain degrees and diplomas on the successful completion of their courses.

The "grandes ecoles" are under the control of different Ministries rather than the Ministry of Education. This affords a better co-ordination of the Ministry concerned with its training institutions, and thus the number of students trained annually is properly controlled and employment assured to successful candidates.

Training in specialized Mining Engineering is given by the following three institutions :—

(1) L'Ecole Nationale Superieure des Mines (Paris)
(2) L'Ecole Nationale Superieure des Mines (St. Etienne)
(3) L'Ecole Nationale Superieure des Mines (Nancy)

Among other mining Schools or engineering schools associated with mining and applied geology may be mentioned the following :—

(1) L'Ecole Centrale des Arts et Manufactures
(2) L'Institut Electro-technique de Grenoble
(3) L'Ecole Nationale Superieure de Geologie Appliquee et de Prospection Miniere de l' Universite de Nancy.

Mining training at junior level is also given at the following mining schools :—

(1) L'Ecole des Mines at Ales
(2) L'Ecole des Mines at Douai

There is a one year's training programme for prospectors giving some theoretical training and greater emphasis for identification of minerals in the field, offered by various organization such as the French Atomic Energy Commission, the Petroleum Prospecting Bureau, the Bureau of Research in Geology and Geophysics for Minerals (BRGGM) and the Bureau of Overseas Territories. Some of these organizations also train Junior Geologists and Mining Technicians.

The Study Group visited the following institutions of higher learning in France :

(1) **Geology Department of the Sorbonne, University of Paris.**—It offers undergraduate and graduate courses in geology, and foreigners are also granted facilities for advanced research in petrology, palaeontology and stratigraphy.

(2) **L'Ecole Nationale Superieur des Mines, Paris.**—This institute, under the Ministry of Industry and Commerce, gives courses in geology to Mining Engineers, Metallurgists, Electricians, Chemists, etc., for assisting them in their particular work or industries. The duration of the course is 3 years and the syllabus consists of the following :—

(a) Theoretical study (physics, chemistry, mineralogy, palaeontology, petrography and geology)

(b) Technical practice (resistance of materials, mechines, industrial electricity, heating and general economics)

(c) Mining exploitation (applied geology, deposits as relevant to ferrous and non-ferrous metals, etc.)

(3) **L'Ecole Nationale Superieur de Geology Appliquee et de Prospection Miniere, Nancy.**—This institute trains Geologists and Mining Engineers at both undergraduate and graduate levels. Foreign students are also taken. Advanced research on geology, mining and ore-dressing is also undertaken in the various up-to-date and well equipped laboratories. The specialized fields of work are (1) minerals related to non-ferrous metals, (2) minerals related to ferrous metals, (3) coals. (4) oil, (5) ground water, (6) geophysical prospecting, and (7) applied geology. The institute has made tremendous progress since I was a student here in 1933.

EAST GERMANY

In East Germany, geology and mining are taught in universities as well as in technical schools. The Study Group visited the Freiberg Mining Academy, and gathered information about several technical schools.

Bargakademie at Freiberg.—Built 190 years ago, the Freiberg Mining Academy (Mining University of Freiberg) has an international reputation and has at present over 2,000 students, including several foreigners. There are 18 departments scattered in thirty-four buildings. The Academy has made considerable progress since I was a student here in 1934. Two year's study after the diploma leads to a Doctorate of Engineering. Advanced research work is carried out in the various fields of geology, mining, ore-dressing and metallurgy.

Students who have completed 12 years in a primary school or those with a good primary education and 3 years of mining experience are considered suitable for admission. The usual age of entry is about 18 years.

Junior Technical Schools.—The training for Junior Geologists, Mining Engineers and Technicians is given in the technical school in Bergbau, Senfleuberg, Zwickau and Eisleben. The age of entry is about 17 years, and only students with 3 years of mining experience are admitted. The objectives of these schools are identical to similar schools in West Germany, where the stress is more towards practical side than on academic learning. Generally tuition is free and allowances for board and for upkeep of dependents are provided.

The duration of the course is generally two years, and a part of time is spent in a mine, The syllabus is planned by a Government Committee. Both written and oral tests are held for the final examination but results of tests during the full period of study are also taken into account. Evening and correspondence course are also held, and external students are given opportunity to undertake a short period of study at a school. Brilliant students on the completion of successful study can study in an institute of higher learning for degree or diploma.

WEST GERMANY

In West Germany, the Study Group visited the Clausthal Mining Academy, the Bochum Mining College, and the Government Geological Survey at Hanover

Bargakademie at Clausthal.—This Mining Academy of the Clausthal University offers training in geology and mining at a high level. It was established 180 years ago as technical high school for the training of Geologists, Mining Engineers, Surveyors and Metallurgists. The present number of student at the Academy is 1,100 inclusive of several foreigners. A student who has successfully completed a three year course is awarded a Diploma in Engineering, equivalent to an university degree. At least two years of advanced work is necessary for a degree of Doctorate in Engineering.

The principal subjects taught are civics, mathematics, chemistry, physics and all subjects related to geology and mining. Summer holidays are spent in a mine. The examinations are taken first after two years and then at the end of the three years' course. The entrance requirements to the Academy is generally equivalent to that needed in France for Baccalaureat part 2, and in addition one year of mining experience is considered essential. On an average 120 new students get admission every half-year (semester).

Bochum Mining College.—An institution designated as "Westfalische Bergwerkschaftaksse", having representatives from the mining concerns of the industrial district of Ruhr, controls the training of Junior Geologists, Mining Engineers and Technicians through five mining schools in West Germany. They are located at Bochum, Essen, Hamborn, Recklinghausen and Dortmund, and have at present 2,190 students. The Bochum Mining College, visited by the Group, is a typical example of such a mining instiution where the emphasis is in the practical field rather than on theory. The various departments are as follows: (a) blasting, (b) percussion tools, (c) electro-technique, (d) mine surveying, (e) geophysics, (f) chemistry, (g) equipment testing, (h) general geology, (i) mine ventilation, (j) mine management, and (k) library and museum.

Only students having worked in a mine are admitted. Normally a student joins a mine at 14 years, and after three years of mining experience he is eligible for admission. In the beginning an entrant attends the college for three days a week, and three days are spent in a mine. The course varies from one to three years. Tuition is free, and a student is entitled to 80% of his usual earnings in a mine.

The certificates issued after passing examinations indicate the subjects studied and act as a reference in case a student has to move from one mine to another.

Additional one year full time courses are offered, after passing the certificate examination, for mine managers specializing in mechanical and electrical equipment. The students get full pay that they would have generally earned as a full-time worker. Students are also given special training for mine deputies ("oberklasse"). A mine deputy with two years of experience in a mine is admitted to the full managerial course.

Government Geological Survey at Hanover—The Department (Amt fur Bodenforschung) also offers two years of training in geology with a view to acquaint them with the functions and activities of a geological survey. On the completion of this training students have to pass a State examination and then appear before a Board. Only successful candidates are eligible for permanent jobs in the Geological Survey.

The candidates for such training must have completed a full course of training either at an university, a technical high school or a mining academy.

Explanation of Figures

Fig 1 & 2.	Lecture Theatre, Gorlovka Mining Technicum, U.S.S.R
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Fig. 4.	Coal Dressing Plant, Donetz Basin, U.S.S R.
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By

B. C. ROY, D I. C., M. Sc. (London), Dr.-Ing. (Freiberg),
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RECENT TRENDS IN MINERAL DEVELOPMENT IN CANADA*

BY

B. C. Roy, D.I C., M.Sc. (London), Dr.-Ing. (Freiberg),
Deputy Director, Geological Survey of India

I. INTRODUCTION

At the instance of the Government of India, the United Nations, under the sponsorship of its Technical Assistance Administration, granted me an Economic Development Fellowship for a period of four months of which May and June, 1957 were spent in Canada and July and August, 1957 in the U. S. A.

During this study tour I held discussions with the State officials and several top-ranking Geologists, Geophysicists, Mining Engineers and Metallurgists. As such, it has been possible to obtain a large amount of information and technical data in a comparatively short time. It is hoped that this paper, reflecting the recent trends in mineral development in Canada, will be of some help to the members of the Geological, Mining and Metallurgical Society of India. The data are largely based on the information collected during my visits to the various institutions, mines, plants, etc., and also include published official data and information from private companies.

I would like to take this opportunity to express my grateful thanks to the United Nations for the award of the Economic Development Fellowship and to the host country Canada. I would also like to record my gratitude to the various

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Federal and Provincial Government organisations and private companies for their kind help and co-operation during my tours.

The Federal and Provincial Geological Surveys and Mines Departments are responsible in a great measure for the proper development of mineral resources of Canada. One is bound to be impressed by the enormous amount of research projects undertaken by the Federal and Provincial agencies, large exploration and mining concerns and universities, in the field of assessment and exploration of deposits, beneficiation of ores and minerals and their economic utilization.

I was able to get a cross section of the great progress made in Canada in the field of mineral development. The national mineral wealth is conserved to eliminate all waste by upgrading of the poor quality ores and by their planned utilization. Everywhere I have noticed intensive large scale geological mapping and prospecting for discovery of new sources of mineral wealth by helicopters, geochemical methods, airborne radiometric and geophysical methods, drilling, etc., by State and private enterprises, involving large capital investments.

The rapid mineral development in Canada has been possible due to several forms of official aid to the industry, e. g., proper mining laws and regulations and mining taxation devised to encourage prospectors and mining enterprises, grants to prospectors, free identification of minerals, etc. The Government make every endeavour to make the public increasingly mineral minded, taking advantages of any agencies capable of assisting in the task, by publication of popular booklets for the laymen, exhibition of minerals and films, etc.

I was greatly impressed by the large annual intake of students from universities for summer employment by the Federal and Provincial agencies and large mining companies and smelters. This not only provides practical training to the students but also solves the problem of recruitment to Government service and in the industries.

The size of Canada is about 2½ times that of the Indian sub-continent comprising India and Pakistan, and yet its population is of the order of 15 millions only. The southern limit with the U. S. A. is bounded by a stretch of some 4,000 miles from the Atlantic to the Pacific coasts. A Federal State with headquarters in Ottawa, Canada comprises 10 provinces. The Federal Authority is concerned with matters of international and national affairs, but the Provincial Authorities have jurisdiction over provincial affairs. The population is largely engaged in agriculture and industry. Much of the industrial progress of Canada has been dependent upon the forest and mineral wealth and the ancillary industries, the harnessing of water power resources for industrial development, etc., but the most significant and tremendous progress has been made in the field of mineral development virtually during the last two decades. The country rightly claims to be the world's third largest trading nation, as the increasing higher yields of base metals, paper pulp, wheat and other commodities, much in excess of her own requirements, make it necessary to export her surplus commodities to other countries. Canada has a very high standard of living and favours immigration of the right type to cover up her man power shortage, concomittant with an ever increasing industrialisation and development of resources of the country.

Topography & Geology. - The Canadian Shield, with its innumerable big lakes and a myriad of small ones, permanently frozen to the north, usually comprises a low relief of less than 200 feet, generally about 2,000 feet above sea level, up to 5,000 - 8,000 feet in certain parts. The *Plains* region around the Shield consists of a level or rolling country, in general 1,500 feet above sea level, rising to 4,000 feet elevation at the foot-hills of the Rocky Mountains ; the Arctic islands are ice capped and the plains to the north are devoid of timber and permanently frozen. The Appalachian Mountains are generally low, the higher regions being timbered. Some of the highest points in the Cordilleran vary from 12,000 to 19,850 feet. Large parts of the Yukon represent permanently frozen terrain, and snow fields and glaciers are common near the Pacific.

The Canadian Shield, a triangular area, comprising Pre-Cambrian rocks, covers about half of the country. The area has been a stable land mass that has not been folded by Pre-Cambrian or later movements. The terrain as in the Indian Peninsula comprises chiefly granitic rocks and large patches of deformed volcanic and sedimentary complexes. Basic dykes and sills intrude both the Archaean and the later rocks. Late Pre-Cambrian volcanic and sedimentary rocks (Proterozoic), generally undeformed, lie on the ancient complex. Horizontally disposed younger strata overlying the sloping flanks on all sides of the Shield, except at the north-eastern Atlantic seaboard, form the second geological unit known as the *Plains.* The sediments comprise early Palaeozoic to Recent formations, not intruded by igneous bodies. The third geological unit, called the *Appalachian System,* consists of a mountainous terrain to the south-east of the Shield and represents highly folded and faulted Pre-Cambrian to late Palaeozoic rocks. They are intruded by granitic and ultrabasic rocks, generally of Palaeozoic age. The orogenic forces from the Atlantic direction folded and thrust the rocks in Eastern Canada north-westward to form the Appalachian region. The fourth geological unit, called the *Cordillera,* lies to the west of the Shield and the Plains, and forms a mountainous region bordering the Pacific ocean. The orogenic forces from the Pacific direction, in late Mesozoic and early Tertiary period, folded and thrust the rocks in Western Canada north-eastward to build the Cordilleran region.

All the four geological units are rich in minerals, each differing in variety and quantity of its mineral wealth. The Canadian Shield yields large quantities of gold, silver, copper, nickel, radium, platinum and cobalt. The Plains produce large quantities of coal, natural gas and salt. The Appalachian region supplies large amounts of salt, gypsum, coal and asbestos, and small quantities of precious and base metals. The Cordilleran region yields large quantities of gold, silver, zinc, copper, lead, coal, oil, bismuth, mercury, antimony and cadmium. The metalliferous ore deposits in the Archaean part of the Shield originated at moderate to great depth, and therefore the mines in Archaean terrains, as elsewhere in the world, are very deep.

II. DEPARTMENT OF MINES & TECHNICAL SURVEYS

Set up in 1950 as a separate Federal Ministry, under a cabinet Minister, assisted by a Deputy Minister, the Department of Mines & Technical Surveys comprises several Government organisations directly or indirectly concerned with the mineral development in the country. Apart from the principal offices and research organisations located at Ottawa, the Department has several offices and research establishments in other parts of the country. The Department comprises six units :— (1) Surveys & Mapping Branch, (2) Geological Survey of Canada, (3) Mines Branch, (4) Dominion Observatories, (5) Geographical Branch, and (6) Explosives Division.

To meet the growing needs of the country's mineral development, in 1956 the Department undertook the largest items of field and research work in its history. The revenue and expenditure of the Department of Mines & Technical Surveys of the fiscal year 1955-56 amounted to $185,949 and $26,930,362, respectively. Construction of new premises for several establishments has begun, and plans for housing the Geological Survey of Canada and the Surveys & Mapping Branch are well under way. This has been found necessary to offset the present inadequate and crammed space, making room for modernisation and extension.

Surveys & Mapping Branch. - It consists of five divisions:— (1) Geodetic Survey, (2) Topographical Survey, (3) Legal Surveys & Aeronautical Charts, (4) Canadian Hydrographic Service, and (5) Map Compilation & Reproduction. In 1956, the Branch consisted of 863 permanent staff in addition to 686 seasonal and 68 part-time employees. There has been an ever-growing demand for maps, charts, and survey information, consequent upon large scale development of resources, defence requirements, etc.

I visited the Topographical Survey Division. In 1956, 209 map sheets covering a total of 79,980 square miles were completed for final drafting and publication. Helicopter equipped parties were responsible for 40% of the detailed mapping. An increasing use is being made of photogrammetrical equipment, leading to greater area of control. The National Air Photo Library Section maintains records of all Federal Government photography and offers facilities to Government Departments and private concerns engaged in development of resources for stereoscopic examination of prints. The Library has a total of 2,339,157 photos. The advance information prints of maps, charts, etc., are supplied to Federal and Provincial Departments as well as to private mining concerns and industrialists. Air photographic coverage is under four styles : - (1) Federal Vertical (R. C. A. F. Vertical and all commercial photography carried out for the Dominion Government),

(2) Commercial & Provincial Vertical, (3) R. C. A. F. Trimetrogon, and (4) R. C. A. F. Oblique.

In 1956, 1,400 maps, charts and plans were printed. The types include topographical, aeronautical, air overprints, Geological Survey of Canada maps, miscellaneous maps and charts, etc. The scales of topographic series are usually 1 : 50,000, 1" to 1 mile, 1" to 2 miles, 1 : 250,000, 1" to 4 miles and 1" to 8 miles. New techniques are being introduced for better, faster and cheaper means of map drafting.

Mines Branch. - This Branch consists of six Divisions :— (1) Mineral Dressing & Process Metallurgy, (2) Radioactivity, (3) Industrial Minerals, (4) Fuels, (5) Physical Metallurgy, and (6) Mineral Resources. In addition, there is a Maintenance Section. In 1956, the Branch consisted of 558 permanent staff and 39 seasonal employees. I visited the Mineral Dressing Section of the Mineral Dressing & Process Metallurgy Division, the Industrial Minerals Division, and the Mineral Resources Division.

There has been a growing demand for the development of new techniques on the extraction of metals and utilization of industrial minerals consequent upon the continued mineral development in Canada. The Mines Branch carries out research projects with a view to assisting the mineral and metallurgical industries in the country. Their main functions are to (1) assist the industry in economic and efficient processing of minerals, ores, fuels, etc., and in their utilization by undertaking laboratory and pilot plant tests and research on ores, minerals and fuels, (2) carry out research on the fabrication of metals and the development of alloys, and assist the defence services and the atomic energy projects in overcoming their metallurgical problems, (3) undertake surveys of mineral resources and their development and utilization, and (4) attend to mining problems on working methods, machinery, costs, etc. Among the highlights of the activities in 1956 may be mentioned the pilot plant testing of processes for treatment of several Canadian uranium ores, and the research and development work in connection with the power reactor project. The Branch also tenders advice to Government from time to time.

The Mineral Dressing Section receives ores, etc., from individuals, prospectors, mining concerns and exploration companies, advises them on economic milling processes, and prepares flow-sheets, etc. Advice is also tendered to the mining companies with regard to improvement in metallurgical processes and techniques. Initially batch tests are carried out on a few pounds of materials, but pilot plant test work on grinding, tabling, flotation, magnetic concentration, sintering and roasting, etc., at rates of 50 lbs. to 1,000 lbs. per hour, is subsequently undertaken if necessary. The major investigations in 1956 pertained to 70 samples of iron ore, iron-titanium ores, nickel ores, copper-nickel ores, manganese ore, niobium ores, complex ores (iron-titanium-gold, silver-lead-zinc, copper-lead-zinc, gold, manganese-tungsten), uranium mill tailing, etc., the large variety of the samples reflecting the growing diversity of the mining and metallurgical industry in Canada.

In the Industrial Minerals Division, there is an ever-increasing demand for research on a diversity of minerals, consequent upon large scale utilization of industrial minerals and their products in the country. In 1956, 1,960 samples were accepted from various Government Departments, private individuals and industrial undertakings for identification, evaluation and processing. As a result of new equipment and milling circuits, several minerals can be processed simultaneously. Besides, 1,600 technical enquiries were attended to. The survey of the industrial water resources in Canada is also handled here.

Recent research on Canadian kyanite has been successful. The kyanite occurs as disseminations in gneisses near Sudbury, in association with quartz, garnet, mica, biotite, etc., whereas Indian kyanite occurs in massive state and is best suited for super-refractories. Recent tests on pilot plant show that the Canadian kyanite could be separated by flotation and calcined to yield a product comparable with products from Indian and African source. I visited the deposit in question and noticed a great deal of exploratory work there, involving expenditure of large sums of money. The property will be worked in the near future when adequate market is established for Canadian kyanite.

The Mineral Resources Division maintains all records of Canadian mineral deposits and related data and statistics. There is an ever-increasing demand for information on the mineral resources as a result of large scale mineral exploration activities in the country. Information is also sought for by foreign companies interested in investment in Canada. In 1956, comprehensive briefs were prepared on the principal metals like nickel, copper, lead, zinc, iron-ore, titanium, aluminium, gold, silver, and the platinum group of metals. The Division maintains a full record of oil reserves of individual companies, cost of exploration, development and production of oil, etc. In 1956, numerous reviews and information circulars on petroleum, natural gas, iron-ore, titanium, rare or less common minerals, principal metals, etc., were prepared, in addition to revised list of coal mines, iron and steel plants, petroleum refineries and milling plants. The Division also undertakes studies on various minerals, trends in mine finance, mining technology, etc., and prepares statistics on mineral production, exports, imports, etc. Field studies are also undertaken to mines and plants to get the latest information The mineral occurrence index and the resources records are always brought up-to-date so that the industry and Government could get full and authentic information on mining properties and deposits. The publications of the Branch are most invaluble and are also brought up-to-date as far as possible.

Geological Survey of Canada. - Established in 1842, the Geological Survey of Canada, with headquarters in Ottawa, is one of the older world Geological Surveys, and has at present a permanent staff of 282 and 285 seasonal employees. The Survey is headed by a Director and consists of six divisions, each under a Division Chief :— (1) Fuels & Stratigraphic Geology (Mr. I. F. Caley), (2) Mineralogy (Dr. S. C. Robinson), (3) Mineral Deposits (Dr. A. H. Lang), (4) Geophysics

(Mr. L. W. Morley), (5) Pre-Cambrian (Mr. C. H. Stockwell), and (6) Post-Precambrian (Mr. L. J. Weeks). The Section Heads are in-charge of Sections under the various Divisions. In addition, there are three units, namely, Geological Manuscripts, Geological Cartography, and Administrative Services. The Geological Editor processes the manuscripts for Departmental publications.

The seasonal employees consist essentially of university undergraduates and graduates, who not only obtain field experience but also form a general pool of trained personnel for future employment in the Survey. Their expenses during the field season are borne by the Survey.

In 1956, 32% of the field personnel and 52% of the field appropriation were assigned to work pertaining to mapping and aero-magnetic surveys to supplement mapping work. About 64,000 square miles of area, excluding airborne geophysical surveys, geochemical surveys and special projects, was covered. Other field projects included detailed or special investigations covering geological problems and mineral surveys. The Survey does not undertake any detailed prospecting or drilling. Field work is confined to summer months, the period being shorter in the northern territories, largely covered by snow in greater part of the year. In lake areas, canoes are commonly used.

In 1956, a study of the correlation between aero-magnetic maps and detailed geological maps in the Eastern Townships, Quebec, has confirmed the Survey's policy, namely, as far as possible, aero-magnetic mapping should precede geological mapping if the latter is to achieve maximum quality and economy.

The Survey publishes Memoirs, Economic Geology Series, Bulletins, Paper Series (mainly preliminary maps and notes), final geological maps, aero-magnetic maps, special reports, topical reports, etc.

The Fuels & Stratigraphic Geology Division has three sections, namely, (1) Stratigraphic Palaeontology, (2) Geology of Fuels, and (3) Engineering Geology & Groundwater, in addition to field offices in Calgary (Western Plains office) and Sydney (Coal Petrography Laboratory). The research activities of the Fuels Division concern projects connected with refining of heavy crude oils and bitumins, geochemistry of petroleum and its origin, pilot-plant projects on the utilizations of solid, liquid and gaseous fuels, recovery of sulphur from crude oils and bitumins, coal geology, coal petrography, etc.

The Mineralogy Division has several sections, i. e., (1) Isotope Geology & Mass Spectrometry, (2) Mineralogy, (3) Geochemistry, (4) Mineral Collection, (5) Analytical Chemistry, and (6) Petrography. Research in Geochemistry section involves field and laboratory work, trace analysis by colorimetric and chromatographic methods, isotope and spectrographic analysis, bio-geochemistry, hydro-geochemistry, geochemistry of ore deposits, etc. Geochemical prospecting is being increasingly used as a valuable tool in the location of hidden mineral deposits in Canada.

The Mineral Deposits Division comprises three units such as (1) Metallic & Non-Metallic deposits, (2) Radioactive deposits, and (3) Radiometric Laboratory. The Geological Survey is an agent to the Atomic Energy Control Board, and reports on work done on newly located uranium discoveries through the Mineral Deposits Division, and maintains up-to-date inventory of uranium and thorium deposits in Canada. The Radiometric Laboratory undertakes identification work, radiometric assays of samples, etc. The actual exploitation of radioactive minerals is undertaken by the Eldorado Mining & Refinery Co , a crown company run on commercial basis.

The Geophysics Division is devoted to application of geophysical methods to geological problems and to improvement of geophysical prospecting techniques. It undertakes airborne magnetometer and scintillation counter surveys, geophysical interpretation, ground geophysical surveys, geophysical surveys in relation to groundwater problems, instrumentation work, etc. In 1956, 154 aero-magnetic maps were compiled on a scale of 1 inch to 1 mile.

The Pre-Cambrian Division comprises three sections, i. e., (1) Eastern Canadian Shield, (2) Western Canadian Shield, and (3) Arctic Islands. Besides, there is a field office at Yellowknife.

The Post-Precambrian Division consists of three sections, i. e., (1) Cordilleran, (2) Appalachian, and (3) Pleistocene, and has field offices in Vancouver and Whitehorse.

I would like to make particular reference to the "Guide for the Preparation of Geological Maps and Reports", published by the Geological Survey of Canada in 1957. The Survey supplies up-to-date information to the public, identifies minerals and rocks free of charge, and supplies cheap standard sets of minerals and rocks. The following extract regarding giving and receiving information pertaining to survey's work, quoted from "General Information for Personnel, Geological Survey of Canada, March 1956", is worthy of mention.

"In giving and receiving information that pertains to Geological Survey work, the administration relies much upon the judgment and discretion of its officers. It is recommended in general that, when information is received, say from a mining company, a clear understanding should be obtained regarding the extent to which the information may be used Discretion should be exercised in accepting and using for publication quantitative data such as assay, values, tonnages of ore, etc.

Information may properly be given orally in advance of a published report in many instances, provided the information thus given to one individual or company will not confer an unfair advantage over another individual or company. It is the practice of the Survey to give advance information on privately owned properties only to the owners or to others nominated by the owners. If such information is other than oral it should be distributed by the Director Undertakings to provide such information other than orally should be kept to a minimum because they interfere with the preparation of Branch publications. Aeromagnetic data should be treated differently and no information is to be divulged prior to public release.

News items from field officers are welcome but before release should be cleared by the Division Chief. If enquiries are received from the press, only information that has been published or cleared by the Division Chief should be given".

Recruitment to the cadre of the Geological Survey of Canada is made through the Civil Service Commission. Annual increment and promotion to senior cadres depend on the satisfactory service and increased usefulness of officers to the Department. The pay scale of the Survey is as follows :—

	(Dollar per annum)
Director	— 13,000 (proposed scale)
Chief Geologist	— — —
Chief of Division	— 10,000 — 10,500 — 11,000
Senior Geologist	— 9,060 — 9,420 — 9,780 — 10,140
Geologist 4	— 8,340 — 8,700 — 9,060 — 9,420
Geologist 3	— 7,260 — 7,620 — 7,980 — 8,340
Geologist 2	— 5,760 — 6,060 — 6,360 — 6,660 —6,960 — 7,320
Geologist 1	— 4,740 — 4,920 -- 5,160 — 5,400 — 5,640

III. PROVINCIAL GEOLOGICAL SURVEYS AND MINES DEPARTMENTS

Except for Yukon and North-West Territories, all Provinces have their own Geological Surveys and Mines Departments for carrying out intensive explorations and mineral development in consultation with the Federal Geological Survey and the Mines Branch. I visited the Ontario Department of Mines, a typical Provincial Mines Department and Geological Survey.

The Ontario Department of Mines is under a separate Ministry of the Provincial Government having a Minister and a Deputy Minister, and is responsible for the administration and enforcement of the various mining acts. The technical services of the Ontario Department of Mines comprise geological surveys, mines inspection, operation of laboratories, preparation of technical information, and publicity. The Department provides a high standard of service to the public and the industry- a factor which has been responsible for successful growth of the mining development in the Province of Ontario.

The Geological Branch of the Department of Mines has its headquarters at Toronto, with a Provincial Geologist as its Chief, about half a dozen Geologists, stationed in important mining centres at Cobalt, Post Arthur, Swastika and Timmins. The Resident Geologists collect and disseminate information regarding prospecting and exploratory results, geological conditions, etc. Several field parties are employed purely in regional systematic mapping. They are headed by permanent members of the staff or university Professors of geology or experienced university graduates, assisted by geology or mining students of

Canadian universities. This practice not only helps the students to get field experience and training, but also helps in the selection of qualified men for the Department of Mines.

No exploratory drilling or prospecting is done, but the work of the Department is of great value to the prospectors and industrialists. Airborne geophysical surveys (magnetometer and scintillometer surveys) are at times carried out, on behalf of the Department of Mines, by private companies. The survey maps are freely and promptly distributed to those interested in developing promising mineral areas. Studies on regional groundwater resources and industrial minerals are also undertaken. The Geological Survey also examines, on behalf of the Mining Lands Branch, all geological and geophysical reports and maps submitted in support of applications for assessment work credit. The Department undertakes free identification of minerals and supplies cheap standard sets of minerals and rocks.

Classes for prospectors are held in winter months in several important mining centres to give free tuition in elementary geology, techniques of prospecting, claim staking, etc Sets of common rocks and minerals are distributed to the classes at a nominal cost.

The Provincial Assay Laboratory is of great help to the prospectors. Claim holders are entitled to free assay coupons upon recording their claims, and upon recording each 40 days' work thereafter. The maximum number of coupons which may be obtained in one licence per year is 18. Identification of minerals and rocks not requiring analysis and tests for radioactivity are made free of charge. Special analytical work includes qualitative spectrographic analyses, radioactivity determinations, rock analyses, etc

The Department of Mines has a Public Relations and Publicity office for dissemination of information with respect to the activities of the Department and the developments in the mining industry. It deals directly with the press, magazines, periodicals and radio, answers questions from individuals, and maintains a library of 16 mm. films of mining interest for display on request. The policy behind is to make the public mineral minded so that they might appreciate the importance of mining in the national and provincial economy.

The Department maintains an excellent reference library for the staff and the public and takes part in periodic exhibitions and film shows, provincial or national. It is claimed that more than half a million people got a fair idea of Ontario's mining industry and of the Ontario Department of Mines by witnessing the recent exhibitions in Toronto and Ottawa. The publications of the Department include Reports, Geological Circulars, Bulletins, coloured geological maps, uncoloured aero-magnetic survey maps, etc.

In 1951, the Department of Mines, with a view to assisting the mineral development in Ontario, set a programme of building roads in the mineral-bearing areas, but at present the Department of Highways does the actual construction and maintenance with funds voted by the Department of Mines.

It is of interest to note that in 1956, the prospectors staked out and recorded altogether 47,997 claims. In the same year, 5,073 new mining licenses were issued and 7,185 were renewed. At the end of 1956, about 105,000 mining claims were in good standing.

IV. MINING-GEOLOGICAL EDUCATION AND RESEARCH

In Canada, both in geology and mining usually 4 years are needed for M.Sc., for matriculates. Research degrees in geology may need up to 3 years or so. Graduate courses in geology are offered by various universities both in Eastern and Western Canada[1], but better facilities for post-graduate work in geology exist in the Universities of McGill, Toronto and Queen's. Master's degree is also given in Mineral Exploration in McGill University. I visited both McGill and Toronto universities and was very much impressed by the standard of work, both at graduate and post-graduate levels.

Mining degrees are offered in the universities of McGill, Queen's, Toronto, British Columbia, Nova Scotia, Alberta, Laval, etc. I visited the Mining Department of Toronto and McGill universities, and was very much impressed by their equipment, library and laboratory facilities, courses of study, etc. Junior level of training in mining technicians is given by the Provincial School of Mines, Haileybury, Ontario. Fresh university graduates in mining may earn $ 350/- a month. On an average, a miner earns as much as $ 400 to $ 500 a month with bonus.

The vacations of the universities coincide with the field seasons of the Federal and Provincial Geological Surveys. Therefore, the students can acquire field experience by working with field parties of the Surveys, and their expenses are borne by the Federal or Provincial agencies concerned. Similarly, mining or metallurgical graduates, during their vacations, work in mining companies, smelters or refineries for gaining experience and are paid for the duration. The International Nickel Co. Ltd. had about one hundred students during my visit, inclusive of 25 geology students, in various spheres of mining, ore dressing, metallurgy, etc. The geophysical exploration companies also employ a number of geophysics graduates or post-graduates on seasonal basis. It is unfortunate that similar facilities for practical training are not generally forthcoming in India, although the Geological Survey of India has been recently offering training facilities to university graduates through its Annual Field Training Programmes.

Application for summer employment of university graduates and undergraduates with the Geological Survey of Canada as Student Assistants and Seasonal

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[1] 'Directory of Geology Departments of educational institutions in the United States and Canada", published by American Association of Petroleum Geologists in 1949, gives valuable information. A similar and up-to-date Directory was issued by the American Geological Institute (Report No 6) in 1952.

Technical Officers, is made through the Civil Service Commission. Graduates get $ 325 to $ 440 a month, and undergraduates $ 220 to $ 280 a month, based upon their academic qualifications and experience, in addition to subsistence and travelling expenses for those assigned to field work. They assist the staff of the Survey in the collection of data for geological mapping, economic investigations, etc. Their initial salary depends on the status of training and experience. Every year recruiting teams from Government Departments and private organisations interview candidates at the various universities. Rating of candidates is done by an Advisory Examining Board comprising a technical member, a departmental representative and an officer from the Civil Service Commission, on the basis of "points" for academic and experience qualifications.

As in India, there is a dearth of qualified Geologists, Mining Engineers, Metallurgists and other technical personnel, for employment in industry and in Federal and Provincial Departments. The universities and the industry actively co-operate to meet the growing needs of such personnel in the country. There is a great strain on the existing facilities in staff and equipment in the various universities.

The industry offers more pay to young recruits and senior personnel. The Chief Geologists in private firms usually get $ 1,200 or more per annum. Recruitment in Government Departments is done through the Civil Service Commission speedily, invariably guided by their technical advisers on the basis of "points" acquired by the candidates. Some of the qualified men leave the industry or Government Departments for more lucrative jobs in the U. S. A.

Every year, the National Research Council of Canada offers numerous Post-doctorate Fellowships in various fields of science, some of which are tenable in the Laboratories of the Department of Mines & Technical Surveys and the Canadian universities. The annual stipend, free of income tax, is $ 3,700 for single Fellows and $ 4,500 for male married Fellows. There is no restriction regarding nationality of applicants. In 1957-58, about 115 Fellowships will be awarded, inclusive of 22 in the Department of Mines & Technical Surveys.

The National Advisory Committee on Research in the Geological Sciences was set up in 1949. There are 22 members of the Committee who represent Federal and Provincial agencies, Arctic Institute, universities, mining and petroleum industry, and Canadian Metal Mining Association. There are eight sub-committees covering the various fields, each being under the Chairmanship of a specialist. The Committee stimulates research by the Federal and Provincial Surveys' universities and other allied organisations, co-ordinates geological research carried in the country, makes recommendations for research projects and secures finances. Strengthening of the technical staff of the Geological Survey of Canada, setting up of new laboratories in that Department and construction of two new multi-storeyed buildings to house the Geological Survey of Canada, provision of large grants to universities, increase in Post-doctorate Fellowships in geology, etc., are the major recommendations, which are now being implemented. In 1956, the total grant made to 8 universities in stimulation of geological research work amounted to $ 40,000.

Throughout Canada there is active co-operation between the Federal and Provincial laboratories and the mineral industry in promoting research work. The large exploration and mining companies have their own up-to-date research laboratories. Their work is mostly connected with exploration of mineral resources, mining, milling, smelting, refining, etc.

The Canadian Technical and Learned Societies also stimulate research by publishing the results of current research projects. Some of the larger societies of national scope pertaining to geology and mining, are listed below :—

(1) Alberta Society of Petroleum Geologists.
(2) Canadian Institute of Mining and Metallurgy.
(3) Geological Association of Canada.
(4) Mining Society of Nova Scotia.
(5) Royal Society of Canada.
(6) Mineralogical Association of Canada.

V. GEOPHYSICAL RESEARCH AND EXPLORATION

The geophysical prospecting methods employed in Canada include magnetic, electrical, gravitational, seismic and radioactive methods. These methods are widely used for the search of oil and exploration companies carry out airborne and ground surveys for location of metallic ore deposits.

Programmes of geophysical research in Canada are being pursued by the Dominion Observatory, Geological Survey of Canada, Provincial Governments, universities, oil companies and several exploration companies. The Dominion Observatory's work is devoted to problems on terrestrial magnetism, gravity and seismology. Eleven seismograph stations are located for recording earthquake shocks in Canada and in other countries.

The Geophysics Division of the Geological Survey of Canada undertakes regional surveys of some 40,000 line miles annually with the help of a Canso aircraft flying an ASQ-3 magnetometer and AEP 1903 R Mark II Scintillation counter. In 1956, 154 aero-magnetic maps were compiled on a scale of 1 inch to 1 mile. The Survey also undertakes geophysical surveys in relation to various problems. The radioactive data are being compiled in the form of maps on a scale of 8 or 16 miles to an inch.

Geophysics is taught in the universities of Toronto, Queen's, McMaster, McGill, Montreal, Laval, Dalhousie and New Brunswick, all in Eastern Canada. Courses in Geophysics are also given in the Western universities of Manitoba, Saskatchewan, Alberta and British Columbia. Dr J. T. Wilson, Prof. of Geophysics, university of Toronto, informed me that during the last decade more than

150 graduates specialising in geophysical prospecting from the university of Toronto have been engaged in search for minerals and oil in the country. The Canadian universities are well equipped to impart sound training in geophysics, and some have specialised in certain branches of geophysics.

During the last decade in particular, applied geophysics has played an important role in the Canadian economy, in the search for oil and minerals. Judging from the diversity of geophysical explorations, the magnitude of work, the amount of money spent annually for such work, etc., as would be evident from the recent trends of mineral industry in Canada, one is apt to believe that Canada probably is the leading country in the world in the field of exploration geophysics. In Western Canada, a sum of $ 30,000,000 is being spent annually for the purpose of geophysical exploration in oil alone. In 1951, 140 separate geophysical parties explored for oil in Western Canada, the figure for 1955 being about 120.

The recent technique of reflection seismology has been successfully employed for mapping subsurface structures relating to oil accumulation, each seismic field party having 15 to 20 on the staff, inclusive of Geophysicists, technical personnel and assistants. Winter operations in the northern territories are undertaken with the help of instruments mounted on snowmobiles. The use of gravimeter and airborne magnetometer has been on the increase due to high cost of seismic operations. In the field of metallic mineral exploration, the recent emphasis has been on airborne magnetometer and scintillometer and on electromagnetic methods. Recent finds of base metal ores and radioactive deposits have been effected by airborne geophysical methods.

I visited the office of the "Canadian Aerosurvey" at Ottawa. The Photographic Survey Corporation Ltd. in Toronto was also visited in the company of Mr. W. H. Godfrey, Vice President and General Manager of the Corporation, Both concerns prepare aerial maps for a wide variety of purposes, for the development of resources, not only in Canada but also in various parts of the world. Maps are also compiled from airborne aero-magnetic, scintillometric and electrical conductivity surveys, on behalf of exploration companies, Federal and Provincial Governments and foreign countries. Excellent geological maps have been compiled from aerial photographs, thus effecting great economy in time and money as compared to conventional field geological mapping. I was greatly impressed by the variety of equipment and aircraft used in aerial surveys by the Photograhic Survey Corporation by a visit to their works at Oshwald airfield in the company of Mr. D. Mackay, Head of Aero-magnetic and Airborne Geophysical Survey.

VI. HELICOPTER SURVEYS

In recent years helicopters are being widely utilized for speedy transport of personnel and equipment as well as for quick airborne surveys. Canada has taken a lead in utilizing helicopters for airborne surveys, particularly in the field of geological mapping. An idea of the helicopter surveys and techniques and equipment successfully employed by the Geological Survey of Canada and their applicability and limitations is briefly dealt with in this Chapter.

In 1952, the Geological Survey of Canada organised the first helicopter operation (Operation Keewatin), mapping 57,000 square miles in 113 days for publication on a scale of 1 inch to 8 miles, costing $ 3.63 per square mile mapped. This is new field technique overcoming the slow, conventional geological mapping work in Northern Canadian Shield. The geological reconnaissance by helicopter was carried out by a party of 16, inclusive of 5 geologists, 1 topographer, 1 radio operator, 3 aircraft pilots 3 aircraft engineers, 1 cook and 2 labourers. As base maps, topo-maps on a scale of 1 inch to 2 miles were used for plotting field observations. About 22,000 aerial photos covering 100,000 square miles were examined to plot areas of rock exposures and their discernible features, for facilitating field work. The equipment comprised 2 Hiller Model 360 helicopters (equipped with floats) and 1 Norseman Mark V aircraft (equipped with skis, wheels and floats).

The Norseman aircraft was meant chiefly for freighting fuels and supplies and camp shifts, whereas the helicopters were used for geological observations. The helicopters could fly 3 to 3½ hours with full tanks, 1 geologist and 1 pilot, flying about 40 miles an hour, at an average height of 300 feet, with lower "swoops" within 10 feet of the exposures at a few miles an hour. Over 1,700 helicopter landings were performed for checking aerial observations or undertaking ground traverses, the helicopters being able to land wherever necessary for examining outcrops, saving miles of surface traverses by conventional geological reconnaissance.

The standard triangular traverse of the radial net comprised a 40-mile flight away from base, a 10-mile flight about perpendicular to this, and a 40-mile flight to base, thus covering about 90 linear miles in 3½ hours' flying time.

Total flying hours both by Norseman aircraft and helicopters were about 990 hours, covering 100 square miles per helicopter-hour, and 815 square miles were examined daily when both helicopters worked.

Features like bedding, ripple marks, phenocrysts, pillows, columnar jointing, intrusive contacts, conglomeratic' pebbles, volcanic breccia fragments, etc., were easily discernible with accuracy. Colour, although helpful at times, was often misleading, needing ground checks. Determinations based on local relief were helpful in distinguishing rock types.

It is claimed that the area would have needed 25 years by conventional ground party mapping (6 men, 3 canoes), on a scale of 1 inch to 4 miles. On a discussion with Dr. C. S. Lord, Chief Geologist, Geological Survey of Canada, who was in-charge of the operations I learnt that helicopter operations are not very suitable for highly forested and mountainous regions, to produce reasonably good geological maps, speedily and economically.

In 1956, the Geological Survey of Canada carried out another helicopter operation (Operation Stikine). A 51-man team, inclusive of 7 geologists and 9 geological assistants, supported by 2 helicopters, 2 fixed-wing aircrafts and pack horses, mapped about 25,000 square miles of North-Western British Columbia, for publication on a scale of 1 inch to 4 miles. This terrain was mapped at less cost per square mile and at several times the pace, in terms of geologist-seasons, of any previous field method. The helicopter technique had again provided a rapid and economic method of reconnaissance geological mapping, as the conventional mapping methods are slow and costly or impracticable because of rugged terrain. As a result of experience gathered regarding operational methods and organisation, another helicopter-supported geological mapping has been planned for Operation Mackenzie in 1957.

VII. EXPLORATION OF IRON ORE DEPOSITS

In this Chapter the activities of the following iron-ore concerns visited by me will be briefly dealt with :—

(1) Algoma Ore Properties Ltd.
(2) Steep Rock Iron Mines Ltd.
(3) Caland Ore Co. Ltd.
(4) Hilton Mine.
(5) Marmoraton Mining Co. Ltd.

Algoma Ore Properties Ltd. – A subsidiary of the Algoma Steel Corporation, the Algoma Ore Properties Ltd. owns the iron-ore concessions at Jamestown, Ontario, 8 miles off Michipicoten harbour on Lake Superior, and connected by the Algoma Central Railway. Hitherto worked as open quarries, the ore body is being exploited since 1950 by underground mining at the Helen, Victoria and Alexander mines, with an annual output of 2 million tons ore, yielding 1.3 million tons of sinter (53.3% of Fe and Mn).

Mining comprises sub-level stoping methods, using long-hole drilling with extension steel. The ore is crushed underground and conveyed to the surface by a conveyor belt. The present underground workings are about 800 feet deep, but three new levels below the 1st and 2nd levels are being driven up to a depth of some 2,000 feet, where the ore reserve has been calculated at 50 million tons.

The general geology consists of Pre-Cambrian volcanic and sedimentary rocks (Michipicoten series), inclusive of the iron formation between acid volcanics below and basic volcanics above. The iron formation comprises the lowermost or siderite member, the middle or pyrite member (pyrite with intercalations of siderite and chert), and the uppermost or banded chert member. The ore body, namely, the siderite member, dips steeply, varies from 40-60 feet to 300 feet in width, and has been worked for some half a mile along the strike. The ore contains patches or disseminations of siliceous, chloritic and micaceous impurities. The intrusive into the Michipicoten series comprise. granites, granodiorites,

diorites and basic dykes. The main geological structure concerns an E.-W. syncline plunging east at 40 to 60 degrees, and five major faults have been located.

Aerial geological survey over a large area is under progress and will be supplemented by ground surveys, both geological and geophysical. A new deposit, 140-180 feet wide, three miles east of Helen mine, containing a reserve of 80 million tons of ore, has been recently proved by drilling to a depth of 3,000 feet.

The company owns an Assay Laboratory where 7,000 analyses are done monthly. Siderite as mined, on an average, contains 35.62% Fe, 7.14% SiO_2, 2.93% S, 1.98% Mn, 2.38% CaO, 5.82% MgO and 1.41% Al_2O_3. The average analysis of sinter is as follows : –

	Natural Per cent	**Dry Per cent**
Iron	50.75	51.13
Manganese	2.87	2.89
Combined iron and manganese	53.62	54.02
Phosphorus	.022	.022
Silica	10.99	11.07
Alumina	1.82	1.83
Lime	2.79	2.81
Magnesia	8.31	8.37
Sulphur ...	.092	.093
Moisture	.74	
Gain by Ignition	1.04	

All underground workings are geologically mapped on 20 feet to inch scale. Reserves are calculated for each mining stage, block, stope and pillar, to be revised periodically. Surface and underground exploration is undertaken to locate ore bodies of sufficient size and grade to warrant mining. The reserves are classified under four categories, namely, direct sinter ore, direct sinter high sulphur ore, sink-float low sulphur ore, and sink-float high sulphur ore.

The highly siliceous ore is beneficiated by float and sink method. The sink-float plant has a capacity of 4,000 tons per day. Siderite has a sp. gr. of 3.60 and the gangue a sp. gr. of 2.40 to 3.10. The ore is separated from the gangue by using a medium of ferro-silicon with a sp. gr. of 3.25. Formerly the separation was done in a cone separator which has now been replaced by a Hardinge heavy media separator. The operation comprises (1) crushing and screening, (2) separation process, and (3) treatment of separated products into float and sink concentrates.

In the sintering plant, the ore and coke are mixed and ignited by oil burners, whereas the ore is sintered to yield a porous lump (oxides of iron), driving off CO_2 and reducing the sulphur content of the ore, the loss in weight being about

30%. The plant capacity is 1.5 million tons per annum. The sinter is partly despatched by rail to the steel plant at Sault Sainte Marie (183 miles) and partly railed to Michipicoten harbour for shipment to lower lake parts in the U.S.A. The yeild of sinter in 1956 amounted to 1.4 million tons. At Sault Sainte Marie, Mr. D. Joyce, Manager of Operations, Algoma Steel Corporation, kindly arranged for my visit to the steel plant.

Steep Rock Iron Mines Ltd.—The Steep Rock iron mines are located 3½ miles north of Atikokan, 142 miles west of Port Arthur on Lake Superior and 40 miles north of the U. S. border. The iron-ore deposit (ore zone) concerns a highly folded and faulted formation, overlying a dolomite and underlying an ashrock (tuff). The area forms a part of the Pre-Cambrian rocks and comprises the so-called Steep Rock group lying unconformably on a granitic complex. The Steep Rock series consists, in a descending order, of (5) interbanded flows, tuffs and sediments, (4) ashrock (pyroclastic tuffs), (3) ore zone, (2) limestone and dolomite, and (1) basal conglomerate.

The ore zone underlies the Steep Rock Lake bottom, and is over 4 miles long and up to several hundred feet wide, persisting beyond a depth of 2,000 feet from the Lake bottom. It consists of a stratigraphically lower part, essentially manganiferous waste (2%Mn) with minor iron-ore, and a upper part consisting mainly of iron-ore (goethite and some limonite and hematite) with negligible manganese and waste bands of cherts and sandy and aluminous sediments. Some pyrite bearing iron-ore is found at the hanging wall.

The origin of the ore was hitherto attributed to hydrothermal replacement, but recent work suggests that the ore bodies represent sedimentary limonite of Steep Rock age, brecciated by compaction and folding, modified by hydrothermal solutions, locally effecting migration of iron. The ore reserve is estimated at 300 million tons (51-58% Fe) per 1.000 feet of depth. The entire output of 3 million tons in 1959 was shipped from Port Arthur to the U. S. A. Ultimate annual shipments from Steep Rock Lake area are estimated at 8-10 million tons.

In order to prove this deposit considerable amount of core drilling was undertaken in the Lake area. Several years of development work and a large capital expenditure were involved before actual production of ore. The Seine river draining into this Lake was diverted elsewhere, and extensive and deep opencasts sunk on the ore deposit by damming off and pumping out water and silt in the middle arm of the Lake. The ore is also recovered by underground mining down to the 2,000-foot level.

The presence of hematite float at the southern shores of the Lake led to the discovery of the deposit in 1937-38. This discovery was followed by core-drilling, and ore intersections were obtained at 2,000 ft. below old Lake bed. A gravimetric survey indicated ore bodies up to a depth of 4,000 feet Airborne magnetometer survey, however, proved misleading as the magnetic high indicated ashrock (tuffs) and the ore is non-magnetic. All the various ore bodies hitherto designated as A, B, C, etc., from time to time, represent a continuous stratigraphic horizon.

The average analyses of ore shipments (1955) are as follows :—

	Steep Rock Lump	
	Dock Per cent	**All-Rail Per cent**
Fe (Natural)	58.028	58.644
Fe	60.64	60.88
P	0.024	0.027
SiO_2	4.21	4.09
Mn	0.15	0.14
Al_2O_3	0 69	0.65
S	0.031	0 028
Moisture	4 31	3.68

The important workings of the Steep Rock Lake Mines Ltd. are designated as (1) Hogarth open pit, (2) Hogarth underground (1,400 feet deep ; A-2 shaft), (3) Errington open pit (now discontinued), and (4) Errington underground (B-1 shaft down to 1,100-foot level). At the last working, the ore is crushed underground and brought up by conveyor belts at the surface to the terminal loading for delivery into the wagons. Dredging operation of the silt overlying the "G-ore body" is in progress, for future open pit mining ; here 50 million cubic yards of silt will have to be removed before open pitting is scheduled to commence in 1959, and underground mining will follow in the future. Underground mining is by block caving method. Exploratory drilling on the "H-ore zone" has given good indication of an ore body.

Geological mapping of the surface and underground working is done on 40 feet to 1 inch scale. Continuous surface and underground core drilling is in progress to delimit the ore bodies for guiding mining operations. Sludge samples from drilling are analysed as a matter of routine for iron, etc.

Caland Ore Co. Ltd.—A part of the Steep Rock Lake (4 sq. miles) is being dewatered and desilted by giant dredgers by this company to reach the iron-ore body, a continuation of the ore body at Steep Rock Lake Mines, at the bottom of the Lake. This is a subsidiary of the Inland Steel Co. of Chicago, Illinois, U. S. A. Since 1958, two dredgers have removed 16 million cubic yards of silt to the settling basin, and the dredging is expected to be complete in 1960. The annual target of ore production has been earmarked at 3 million tons annually. Apart from dredging, progress has been maintained in other phases of development, namely, Caland highway, Julian airport, pit access road, Fairweather dam, railroad, shaft sinking, preparation for open pit production, etc.

Hilton Mine.—This area in Quebec was being worked in a very small way many years ago, and beneficiation tests of ore were made by the Mines Branch, Ottawa, in 1909, 1928 and 1941. Exploration programme in 1950 covering 15 000 feet of core drilling by W. S. Moore Co. of Duluth, Minnesota, has proved large tonnages of low grade magnetite ore, in association with granite-gneiss, amphibolite and limestone, enough for 15-year supply, by open pit mining. The exploratory holes are spaced at 200-foot intervals, their maximum depth being 500 feet. Apart from magnetite, the principal ore constituent, some amount of pyrite, pyrrhotite and hematite is present. The ore bodies are in the form of lenses up to 70 feet wide and dip 60° to 70° north.

The crude ore contains 35% Fe and the concentrating will be done by crushing, magnetic separation, etc. The run of mine ore will undergo about 20 stages to produce pellets suitable for blast furnace or open-hearth feed. The pellets will have a composition as follows :—66.2% Fe, 3% SiO_2, 0.006% P, and 0.11% Mn. The crushing plants, magnetic concentrating units and pelletizing plants are under construction, scheduled to cost $ 16 million.

Overburden is being removed from an area of half-a-mile by quarter of a mile for commencing open pit operation. Production is anticipated by the end of December, 1957.

The overall feed at the primary crusher will be 8,000 tons daily, yield ing 2,000 tons of concentrates daily. Half of the yield (pellets), 6,000 tons per annum, will be utilized in Canada (Steel Co. of Canada's plant, Hamilton), and the rest will be shipped to the U. S. A.

Marmoraton Mining Co. Ltd.—Located south-east of the township of Marmora, Ontario, the Marmora iron-ore deposits are worked by the Marmoraton Mining Co. Ltd. The discovery was brought about as a result of aero-magnetic surveys undertaken by the Geological Survey of Canada for the Ontario Department of Mines in 1949. The work was followed by ground gravity and magnetic surveys and 37,000 feet of diamond drilling to prove 17 million tons of low grade ore (37% Fe). Stripping of 130 feet of limestone had to be undertaken to work the deposit, and in 1955 the crushing, concentrating and pelletizing plants went into operation. The ore after crushing and coarse magnetic cobbing, is ground, concentrated magnetically, and pelletized in oil-fired, vertical shaft furnaces. In 1956, 531,425 tons of ore were milled to yield 289,565 tons of concentrates averaging 66. 48% Fe, preducing 290, 981 tons of iron-ore pellets. The pellets are shipped to Bethlehem Steel Co.'s plant near Buffalo, U. S. A.

VIII. EXPLORATION OF ORE DEPOSITS FOR NON-FERROUS METALS

In this Chapter the activities of the following companies, as noticed during my visits to their mines, mills, smelters, etc., are outlined in brief :—

(1) International Nickel Co. of Canada Ltd.
(2) Falconbridge Nickel Mines Ltd.
(3) Consolidated Sudbury Basin Mines Ltd.
(4) Faraday Uranium Mines Ltd.

International Nickel Co. of Canada Ltd.—The International Nickel Co. of Canada is reputed to be the world's most important nickel producer, is one of the biggest producers of the world of platinum metals, and is the leading producer of copper and cobalt in Canada. Located in the Sudbury basin, the working mines are the Creighton, Frood-Stobie, Garson, Murray, Levack and the Frood opencast, the total underground development up to the end of 1956 being of the order of 410 miles. In 1955, the company undertook 523,000 feet of exploratory surface diamond drilling.

The elliptical shaped Frood opencast is about 500 feet deep and has 60-foot high benches. Hitherto largely worked by opencasts, the Frood-Stobie mine is being worked by underground operations. The mine is operated by four shafts, the deepest part below the 58 level being about 6,000 feet from the surface. No. 4 shaft is about 4,000 feet deep. No. 3 shaft is about 3,000 feet deep and is capable of raising 10,000 tons ore daily. The present output is about 13,600 tons of ore daily. The Levack mine is over 2,500 feet deep and yields about 4,000 tons daily. The Garson mine, worked by two shafts, one over 4,000 feet deep, yields 6,500 tons daily. The Murray mine having underground working up to 3,300-foot level, yields 6,500 tons daily. The underground mining methods include shrinkage stoping, square-set mining, cut-and-fill mining, induced caving and blast-hole mining.

The ore consist essentially of pyrrhotite, pentlandite and chalcopyrite, and some pyrites and arsenides of nickel, cobalt and platinum. The ore bodies occur as breccias, massive bodies, disseminations and stringers, and are found at the outer contact of the nickel eruptive and along offsets from the same. The host rocks comprise quartz-diorite, norite, granite, quartzite, andesite, gabbro and breccias, the structures favourable for the deposition of ores being faults, breccia zones, etc. The ore reserves are estimated at over 265 million tons averaging 2% of nickel and copper.

In order to treat a very large output of ore (14.4 million tons in 1954), the company operates two concentrators at Copper Cliff (30,000 tons daily) and Creighton (12,000 tons daily). The latter produces a bulk sulphide flotation concentrate which is piped to the Copper Cliff concentrator where it enters the regular circuit for selective flotation. The final copper and nickel concentrates are conveyed to the copper smelting and nickel smelting operations respectively. The company owns smelters at Copper Cliff and Coniston, a copper refinery at Port Colborne, a precious metal refinery at Copper Cliff, etc. A plant has been recently set up to recover iron-ore from the pyrrhotite concentrates (by-products). In 1956, 91,000 tons of iron-ore were produced.

Production.

			1955	1887-1955
Ore shipped	....	tons.	14,247,591	239,396,885
Nickel	...	lb.	279,664,452	6,602,885,521
Copper	....	lb.	265,344,869	6,988,535,250
Cobalt	....	lb	1,479,477	6,312,587
Selenium	...	lb.	94,465	2,349,906
Tellurium	....	lb.	6,455	153,227
Platinum metals	....	oz.	316,816	6,897,312
Gold	....	oz.	42,167	1,408,370
Silver	....	oz.	1,374 583	44,490,119
Total value	...		$299,345,535	$3,621,801,798

Falconbridge Nickel Mines Ltd.—Situated in the Sudbury basin, the Falconbridge Nickel Mines Ltd. comprise the producing mines of Falconbridge, Falconbridge East, Mount Nickel, Mckim, Hardy and Longvack. The most important Falconbridge mine has levels up to a depth of 4,000 feet, and one shaft is being extended down to a depth of some 6,000 feet, Mckim mine has a 1,421-foot shaft and Falconbridge East mine has levels to a depth of 2,800 feet. Mount Nickel has a 800-foot deep shaft and the Hardy mine shaft is 1,427 feet deep. Longvack mine is being developed by an inclined shaft.

The company's surface drilling operations in 1956 amounted to 92,000 feet to a depth of 4,000 feet. The ore reserves are indicated at over 45 million tons averaging 1.43% Ni and 0.75% Cu.

The ore bodies at Falconbridge and Falconbridge East mines occur in fault zones along the norite-greenstone contact at the south-east margin of the basin. The ores are pyrrhotite, pentlandite and chalcopyrite and occur as breccias, massive bodies, disseminations. The south rim of the nickel eruptive contains the Mckim and Mount Nickel mines whereas the north rim holds the Hardy and Longvack mines.

Underground workings are mapped on a scale of 20 feet to 1 inch, but permanent records are kept on a scale of 40 feet to 1 inch. Stope control maps (20 ft. =1 inch) are prepared for actual mining work.

The company operates a concentrator at Falconbridge having a capacity of 2,500 tons daily. The smelter at Falconbridge has three blast furnaces and four converters. The nickel-copper matte is shipped to the company's refinery at Kristiansand, Norway, for separation and refining of nickel, copper, cobalt and precious metals. In addition, the company operates a concentrator at the Hardy mine and a pilot plant for the treatment of pyrrhotite concentrates at Falconbridge.

Production

		1955	1930-55
Ore shipped ...	tons.	1,681,875	17,553,544
Nickel ...	lb.	37,357,523	470,495,813
Copper ...	lb.	21,290,712	247,277,176
Cobalt ...	lb.	603,007	1,904,074
Platinum metals ...	oz.	22,930	141,954
Gold ...	oz.	3,966	36,118
Silver ...	oz.	106,145	816,735
Total value ...		$ 32,853,578	$ 213,500,133

Consolidated Sudbury Basin Mines Ltd.—The Cu-Pb-Zn deposits in the Sudbury district are being worked by the Consolidated Sudbury Basin Mines Ltd. Dr. J. E. Thomson of the Ontario Department of Mines, accompanied me to the area. There are two mines, the Errington and the Vermilion, located four miles apart. They occur at the contact of underlying tuffs and overlying slate of the Whitewater series of volcanics and sediments, as replacements of a limestone horizon. The ores consist of pyrite, sphalerite, chalcopyrite, pyrrhotite and galena in a carbonate matrix. At the Errington mine, the ore bodies are found on the crest and south limb of a south dipping anticline, the structure being complicated by a group of strike faults slicing the anticline into at least four blocks. The south limb is yet to be explored. The ore horizon dips 40°S at the Vermilion mine where repetition of ore bodies occurs due to complex thrust faults.

The total ore reserves at both mines are estimated at 13.2 million tons, averaging 1.14% Cu, 0.90% Pb, 3.85% Zn, and 0.018 oz. Au and 1.51 oz. Ag per ton. In No. 3 shaft area 850,000 tons of ore are present.

At the Errington mine there are three shafts, the deepest one extending to the 1,500-foot level. Here over 125,000 feet of surface drilling was undertaken. The underground work is altogether 41,000 feet, on four levels. The development at the Vermilion mine comprises extensive surface and underground drilling, and a shaft down to 1,250 feet with underground workings at 450-, 600-, 750-, and 900- foot levels. A large part of the underground development lies below the Vermilion river.

A new mill with a daily capacity of 1,000 tons is being erected at the Vermilion mine to treat eventually 3,000 tons daily. The ore from the Errington mine is being treated, since many years, for the recovery of Cu, Pb and Zn.

Faraday Uranium Mines Ltd.—The mine is located five miles west of Bancroft, Ontario, and has a total personnel of about 380. No. 1 shaft is 865 feet deep and is connected by an adit and several levels (150-foot, 300-foot, 450-foot, 600-foot and 750-foot). No 2 shaft is 180 feet deep and is connected to the 150-foot level. The exploration and development comprise surface diamond drilling (85,777 ft.), underground diamond drilling (63,118 ft.), cross-cutting (9,033 ft.), drifting (14,674 ft.)

and raising (5,320 ft.). The company holds a $ 29,754,800 contract for the sale of uranium precipitates to the Canadian Government.

Uranium occurs as minerals of the uraninite-thorianite series as disseminations in granite pegmatites in the Pre-Cambrian Shield. The deposits are tabular, 60 to 340 feet long and 6 to 100 feet wide. The ore is concentrated at the margin of the pegmatites averaging 0.112% U_3O_8. The pegmatite masses vary in size from 300 to 3,000 feet in length and 10 to 150 feet in width, persisting at depth beyond 1,000 feet and dipping 50°-60° south-east. Criteria for the presence of mineralisation are hematite staining, abundance of ferromanganesian minerals, including augite and hornblende, presence of inclusions of country rocks, and presence of magnetite. Thorium appears to be co-extensive with the uranium in a fairly constant proportion of 1 part of thorium to 2 uranium. Cerium, gallium and zirconium are present but their economic importance is yet to be determined.

The mill has a capacity to treat 1,000 tons of ore per day. Uranium is recovered by acid-leach and iron-exchange precipitation process. The reagent consumption in milling is as follows :—

Sulphuric acid	...	60	lb/ton	milled
Sodium chlorate	...	1.5	,,	,,
Jaguar MD-C	...	0.5	,,	,,
Supercell	...	0.4	,,	,,
Salt	...	4.0	,,	,,
Magnesia	...	1.5	,,	,,
Sodium sulphate	...	0.1	,,	,,
Burned lime	...	24	,,	,,
Rods	...	0.75	,,	,,

IX. MINERAL INDUSTRY

Canada is very rich in mineral wealth either actual or potential. The actual reserves pertain to known mining areas, and very little is known regarding the potential reserves, particularly when one considers the fact that about 80% of the country is yet to be mapped geologically. Judging from the large territory to be covered for mineral exploration, where new sources would be located, it would appear that the country can look favour to an era of greater prosperity in mineral industry.

The production of structural materials and commodities such as coal will be largely dependent upon the growth of local population and industry, but the metalliferous deposits could be worked to yield increasingly higher outputs as the metals and their products could be shipped to distant countries. There is a world wide drain on metals and natural fuels, and the inaccessible and less developed regions are bound to be explored to find new sources.

In 1886, the total value of all minerals produced in Canada was $ 10,221,255. In 1901, the figure rose to about $ 65,000,000 and the production doubled

($ 130,000,000) by 1915. The value of annual production dropped to about $120,000,000 during the general world depression from 1929 to 1932. Abnormal conditions prevailed from World War II in 1939 up to 1945. In 1942, the annual value of mineral productions was $566,768,672. In 1950, the figure rose to about $1,000,000,000.

Ranking as one of the world's leading mining countries, the annual value of mineral production in Canada in recent years amounted to over $ 1 billion, with a record of above $ 1.7 billion in 1955. This great achievement has been possible due to increase in output of crude petroleum in Western Canada, rapid growth of uranium mining, and continued expansion of production of iron-ore and base metals.

In the world production, the country ranks, first in asbestos and nickel, second in gold, zinc, cadmium, cobalt, aluminium, magnesium and platinum, third in barite and silver, and fourth in copper and lead, and possibly also in uranium. The position regarding iron, oil and natural gas has been steadily on the increase.

During the peak year for gold production in 1941, with 144 mills, Canada produced 5.3 million ozs. with value of $ 205.7 million. In 1955 the gold production, with 48 mills, amounted to 4.5 million ozs valued at $ 157·3 million. The Emergency Gold Mining Assistance Act, extending up to 1956, provided $ 9,300,000 or $ 3.10 a production ounce by way of cost-aid payments by the Federal Government.

In 1955, the value of copper, lead and zinc output totalled $ 411 million, and capital expenditure in development work in the base metal areas amounted to over $ 630,000,000. About 45 companies represent the principal base metal producers. In 1955, nickel output was 349,857,000 lbs-a peak production ; production of cobalt amounted to 2,999,650 lbs.

Canada, the world's leading exporter of aluminium, does not possess any deposit of bauxite and yet the country is the second largest producer of aluminium in the world, next to the U.S.A. The Aluminium Co. of Canada is the only producer, although a new producer, the Canadian British Aluminium Co., was scheduled to start production in 1957.

The main output of silver is from by-product in the base metal industry, although there are several firms producing silver as the principal metal.

Uranium production will augment considerably when the new sources in the Beaverlodge area (N Sask.) and in Blind river and Bancroft areas (Ontario) go into production. The Crown Corporation Eldorado Mining & Refining Ltd . has signed contracts totalling over $ 1,000,C00,000 for uranium oxide precipitates in the Blind river area, which has attained a global fame in recent years. The Consolidated Denision mine, in this area, with ore reserves of 136,000,000 tons valued at $3,800,000,000 is reputed to have more than double the total reserves of all uranium mines in the U.S.A. The present and planned sales contracts for uranium oxide precipitates in Canada are estimated at over $ 1.25 billion.

In Canada there was no output of iron-ore up to 1937, and till then imported ores from the U.S.A. and Newfoundland were used in the country's iron and steel industry. Since World War II, particularly from 1950, there has been a growing activity in exploration, development and production of iron-ore, and in 1954 the country occupied the seventh place among the world's producers of iron-ore. Production of iron-ore in 1955 attained a record of 17.3 million tons (7.3 million tons in 1954). The output is likely to be doubled in next few years, when all the mines of Iron Ore Co. of Canada, Caland Ore Co. Ltd., Steep Rock Iron Mines Ltd., Falconbridge, Noranda and Hilton go into full production.

The recent development of the titanium rich iron-ore deposits of Quebec, with reported ore reserve of 150 million tons of ore, for the production of pig iron and titanium dioxide, would in future make Canada the world's leading titanium producer to the detriment of Indian ilmenite trade.

In 1955, the value of exports of metals, minerals and their products totalled $ 1,431,000,000 amounting to 33.4% of Canada's total export trade of $ 4,282,000,000. 77% of the exports of iron-ore as also most of exports of base metals (Cu, Pb, Ni & Zn) went to the United States.

In 1955, there were altogether 715 metal mines and smelters, 12,000 oil and gas wells, 225 coal mines, 940 non-metallic mines and quarries, and 7,800 sand pits. The industry during this period employed about 130,000 persons, and their salaries and wages totalled $ 465,000,000.

Prior to the discovery of oil and natural gas in Alberta, Saskatchewan, Manitoba, etc., the country was dependent on imports to the extent of 90% of her needs. In 1955, output of crude oil was 129,440,000 barrels, valued at $ 305,640,000. In 1955 over $ 500,000,000 was spent on exploration and development of oil and natural gas resources in Western Canada. At the end of 1955, Canada had 5,069 miles of oil pipeline, spent about $ 101, 000,000 on oil refinery construction, and had 42 refineries in operation. There are about 200 companies carrying out exploration and production of oil and gas. Of late there has been a marked progress in the exploration and planned development of the natural gas fields.

In 1955, the value of production of industrial minerals totalled $ 373,153,000 particularly in view of augmentation of construction works and chemical industries. The important production was in asbestos, cement and gypsum. The country's total planned production of cement is anticipated as 34,000,000 barrels, twice the output of 1950. Important developments occurred in the production of lithium, rock-salt, potash, fluorspar and sulphur. In 1955, sulphur production from by-product pyrites and smelter gases amounted to 628,400 tons ; during the same period 26,000 tons of elemental sulphur were produced from natural gas. Further use of Canada's resources of sulphur is under way as would be evident from the activities of Noranda Mines Ltd., Shell Oil Co. of Canada, Royalite Oil Co. Ltd. and Canadian Gulf Oil Co.

Mineral Production

	1955		1954	
	Quantity	Value ($)	Quantity	Value ($)
Aluminium-ingot	584,153 tons		560,886 tons	
Antimony	985 tons	536,575	651 tons	349,249
Bismuth	207,670 lbs	422,333	258,675 lbs	572,183
Cadmium	1,971,012 lbs	3,350,720	1,086,780 lbs	1,847,526
Chromite[1]	...	...	...	...
Cobalt	2,999,650 lbs	7,723,500	2,252,965 lbs	5,912,997
Copper	324,604 tons	239,394,952	302,732 tons	175,712,693
Gold	4,553,520 ozs	...	4,366,440 ozs	...
Lead	193,374 tons	55,786,929	218,495 tons	58,250,831
Magnesium[2]	...	...	...	...
Manganese[3]	...	...	...	...
Molybdenum (contained MoS_2)	645 tons	806,184	376 tons	457,912
Nickel	174,581 tons	216,433,694	161,279 tons	180,173,392
Niobium (Nb_2O_5)	42 lbs	1,032	90 lbs	2,294
Tantalum (Ta_2O_5)	390 lbs	9,760	77 lbs	2,696
Platinum metals	381,620 ozs	22,833,000	343,706 ozs	20,906,556
Selenium	431,000 lbs	3,009,000	323,529 lbs	1,617,645
Silver	27,901,427 ozs	24,625,797	31,117,949 ozs	25,907,870
Tellurium	6,000 lbs	11,000	8,171 lbs	14,300
Tin	177 tons	316,600	149 tons	263,359
Titanium				
(Ilmenite)	445,635 tons		304,550 tons	
(Rutile)	117,042 tons	5,192,810	88,408 tons	3,841,270
Uranium	..	26,000,000[4]	...	...
	..	23,000,000[5]	...	...
Tungsten (WO_3)	1,141 tons	6,465,638	1,085 tons	5,795,781
Zinc	426,966 tons	116,425,122	376,491 tons	90,207,285
Arsenic (As_2O_8)	650,000 lbs	29,250	1,180,350 lbs	48,333
Asbestos	1,055,266 tons	98.690,514	924,116 tons	86,409,212

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[1] No known deposits of commercial grade ores. Chromite is imported for production of ferro-chrome.

[2] Brucite & dolomite are raw materials. Production capacity 11,000 tons annually.

[3] No production of ore. Produces ferro-manganese from imported ore.

[4] Total production value.

[5] Value of sales of refined uranium oxide,

	Quantity	Value ($)	Quantity	Value ($)
Barite	253,736 tons	2,277,166	222,472 tons	2,003,796
Cement	25,860,103 barrels of 350 lbs	64,363,165	22,437,477 barrels of 350 lbs	59,035,644
Clay & clay products		34,676,067		32,360,098
Feldspar	18,844 tons	370,968	16,096 tons	301,049
Fluorspar	131,728 tons	3,063,876	118,969 tons	2,987,026
Granite	3,195,421 tons	6,121,344	12,834,727 tons	13,041,999
Graphite[6]	...	...	2,463 tons	254,534
Gypsum	4,798,200 tons	8,455,173	3,950,422 tons	7,094,671
Iron-ore	14,536,000 tons	110,000,000	6,572,855 tons	49,666,507
Iron oxide pigment (natural and manufactured)	7,467 tons	144,369	5,798 tons	183,507
Lime	1,303,499 tons	15,190,328	1,214,839 tons	14,742,149
Limestone (General)	22,612,479 tons	29,901,480	18,829,748 tons	25,144,026
Limestone (structural)	88,202 tons	2,785,223	87,922 tons	2,745,482
Magnesite & Brucite	...	2,151,820	...	4,394,280
Marble	63,246 tons	526,416	57,748 tons	633 702
Mica	1,186,235 lbs	75,004	1,706,770 lbs	85,139
Nepheline syenite	146,068 tons	2,099,512	123,669 tons	1,770,529
Salt	1,244,761 tons	10.122,299	969,887 tons	8,340,163
Sand & gravel	123,655,944 tons	65,754,176	110,961,034 tons	58,987,671
Quartz & silica sand	1,858,879 tons	2,006,744	1,716,151 tons	1,574,893
Sodium sulphate (natural)	170,801 tons	2,759,034	158,417 tons	2,385,573
Sulphur & pyrites (sulphur content)	654,237 tons	...	551,071 tons	
Talc & soapstone	28,100 tons	334,100	28,143 tons	335,353
Whiting & whiting substitute	16,764 tons	181,169	16,913 tons	181,112
Coal	14,818,880 tons	93,579,471	14,913 579 tons	96,600,266
Coke	4.301,857 tons		3,668,726 tons	52 823,422
Natural Gas	151.326.408 (M. cu. ft.)	15,265,471	120,735,214 (M. cu. ft.)	12,482,109
Peat moss	126,687 tons	3,330.810	99,272 tons	3,018,622
Petroleum	129,452,523 (barrels)	305,375,847	96,080,345 (barrels)	243,877,030

Exploration Companies:—I held interesting discussions with officers of the **Northern Miner** in respect of publication of news on mining activities in Canada. I understand that the Canadian mining companies spend a total of about $27,000,000 annually, on exploration, and it is probable that the figure for the country as a whole, including that spent by American and other companies, as well as by the numerous Canadian companies not associated with producing mines, might be of the order of $ 100,000,000 annually. A list of some leading exploration companies is given below :—

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[6] No production in 1955.

1. International Nickel Co. of Canada Ltd.
2. Kennco Explorations (Canada) Ltd.
3. American Metals Company Ltd.
4. Conwest Exploration Company Ltd.
5. Anaconda Company (Canada) Ltd.
6. Asarco Exploration Co. of Canada Ltd.
7. Ventures Limited.
8. McIntyre Porcupine Mines Ltd.
9. Rio Tinto Mining Company of Canada Ltd.
10. Falconbridge Nickel Mines Ltd.

New Mills and Mining Plants :—A list of mills and mining plants, completed or under construction in 1957, after **Northern Miner**, is given below :—

Company	Plant Capacity (tons/days)	Product	Area	Remarks
Algoma Ore	...	Iron	N. Ont.	Building 500,000-ton addition to sinter plant ; also readying Sir James (Britannia) open pit.
Arcadia Nickel	1,000	Nickel	N. Ont.	Mill being installed.
Caland Ore	...	Iron	N. W. Ont-	Preparing for output of 3,000,000 tons yearly by 1960.
Canadian Dyno	1,100	Uranium	S. E. Ont.	Production to start in March, 1958.
Can-Met Explor	3,000	Uranium	N. Ont.	Output stated for July.
Carey Canadian	2,000	Asbestos	Quebec	To be finished in late 1957.
Cobalt Cons	300	Silver	N. Ont.	Mill ready in June.
Cons. Denison	6,000	Uranium	N. Ont.	3,000-ton unit started in April ; second unit by Aug.
Cons. Sudbury	3,000	Cu-Zn-Pb	N Ont.	First 1,500-ton unit to start in Aug. ; roast-leach plant planned.
Coldstream Copper	1,000	Copper	N.W. Ont.	Production expected by 1957.

Company	Plant Capacity (tons/days)	Product	Area	Remarks
Eldorado Mining	1,250	Uranium	N. Sask.	Addition (now in operation) boosts capacity to 2,000 tons per day.
Empire Develop	3 000	Iron	B. C.	To be completed in May.
Falconbridge :				
Main mine	...	Ni-Cu	N. Ont.	Smelter addition near completion.
Fecunis mine	2,000	Ni-Cu	N. Ont.	In operation shortly.
Faraday Uranium	750	Uranium	S. E. Ont.	Output started in March ; eventually will be 1.000 tons.
Hilton Mines	...	Iron	Quebec	600,000-ton yearly ; concentrator being built.
Geco Mines	3,300	Cu-Pb-Zn.	N.W. Ont.	Production in 1957.
Heath Steele	1,500	Pb-Zn-Cu	N.B.	Turning up started early 1957 ; railway under way.
Hollinger N. Shore	...	Iron	Ungava	Ferriman mine scheduled to produce in 1957.
Inter. Nickel :				
Thomson-Moak	10,000	Nickel	N. Man	Concentrator and smelter to produce in 1960.
Levack	6,000	Ni-Cu	N. Ont.	Concentrator to be in production in 1958.
Lake Asbestos	4,000	Asbestos	Quebec	Target date is latter part of 1958.
Lowphos Ore	...	Iron	N. Ont.	Plans 500,000-ton output by 1958.
Lorado Uranium	500	Uranium	N. Sas	Now starting production.
Magnet Cove	....	Barite	N. S.	Planning open pit mine.
Maritimes Mining	2,000	Copper	N'fld.	To start in August.
Merrill Island	750	Copper	N.W. Que	Finish in 1958.
Milliken Lake	3,000	Uranium	N.Ont.	Output stated for March, 1958.
National Asbestos	3,000	Asbestos	S. Que	Construction to be completed in 1958.
N'fld. Fluorspar	...	Fluorspar	N'fld.	To raise capacity 50% to 110,000 tons by year end.
Northspan Uranium	9,000	Uranium	N. Ont.	Three mines to start in summer.
North Rankin	250	Nickel	N.W.T.	Expected to reach capacity in June.

Company	Plant Capacity (tons/days)	Product	Area	Remarks
Phoenix Copper	700	Copper	B. C.	Mill under construction.
Potash Company	4,500	Potash	Sask.	First commercial output by Nov., 1958.
Rayrock Mines	150	Uranium	N.W.T.	Mill to start in June.
Sherritt Gordon	...	Nickel	Sask.	Refinery expansion in progress.
Stanleigh Uranium	3,000	Uranium	N. Ont.	Production this fall.
Stanrock Uranium	3,000	Uranium	N. Ont.	Production this fall.
Weedon Pyrite	300	Cu-Zn	S. E. Que.	Mill: 400 tons by August.
Western Nickel	...	Nickel	B. C.	Concentrator to be built by Granby Consolidated.
Willroy Mines	1,000	Cu-Zn	N. W. Ont.	Output in August.

Mining Laws & Regulations—The nature of mining laws and regulations and mining taxation, as prevalent in Canada, has facilitated the mineral development in a spectacular way. Ownership of public lands and minerals vests either with the Provincial or Federal Authority. The Federal Authority looks after the provision of the Federal mining laws, labour safety, conservation, etc., and the Provincial Governments generally control the development of mineral deposits according to Provincial minings acts. Any one, even foreigners or visitors, having a Miner's Licence, granted on the basis of a nominal annual fee, may prospect in all Crown lands and stake out claims. The person merely marks out the limits of his claim, records its location with the authorities, and secures his right to work the property. Provided some prospecting has been carried out on the claim, mining leases are granted for specified periods with options of renewal at specified rentals and royalties, depending upon Provincial regulations. The claims are transferable.

I would like to draw attention to the "Summary Review of Federal taxation and certain other legislation affecting mining, oil and natural gas enterprises in Canada", prepared by the Mineral Resources Division (April, 1957), for general information, but reference may be made for details to the statutes.

Federal income tax law provides encouragement to individual prospectors and mining companies in the form of exemption from tax on income from first 36 months of production, deduction for tax all expenses on exploratory works, exemption from tax all profits on stock exchange, etc. The provision of "grubstake grants" to prospectors in certain Provinces is an incentive to the mining industry.

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EXPLORATIONS FOR MINERALS IN THE U.S.A.*

BY
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Deputy Director, Geological Survey of India

I. INTRODUCTION

Under the sponsorship of the Government of India, the United Nations Technical Assistance Administration granted the author an Economic Development Fellowship in Canada and U. S. A., for a period of four months during 1957.

This paper gives an idea of the recent trends in mineral development in the U. S. A., and it is hoped that it will be of some help to the members of the Geological, Mining and Metallurgical Society of India. The author had the benefit of discussions with several leading Geologists, Geophysicists, Mining Engineers and Metallurgists. As such, it has been possible to obtain a large amount of information and technical data in a comparatively short time. The data given in this paper are largely based on the information collected during his visits to the various institutions, mines, plants, etc., but also include published official data and information from private companies.

The grateful thanks of the author are due to the United Nations for the award of the Economic Development Fellowship, and to the host country U. S. A., for making the visits most interesting and profitable. The author would also like to record his indebtedness to the various Federal and State Government organisations and private companies for their kind help and co-operation.

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Government initiative from the Federal and State Geological Surveys and Bureau of Mines, with their ever increasing technical personnel and up-to-date laboratories and equipment, adopting modern techniques, is responsible in a great measure for the development of mineral industries in the U. S. A. and one is very much impressed by the magnitude of research projects undertaken by the Federal and State agencies, large exploration and mining concerns and universities, in the field of assessment and exploration of deposits, beneficiation of ores and minerals and their economic utilization. There is a close co-operation between the research organisations, universities and the industry, leading to a quicker appraisal of mineral deposits by newer techniques, their exploration and better utilization of raw materials.

In the U. S. A. the national mineral wealth is conserved to eliminate all waste by upgrading of the poor quality ores and by their planned utilization. Everywhere intensive large scale geological mapping and prospecting for discovery of new sources of mineral wealth by geochemical methods, photogeological studies, airborne radiometric and geophysical methods, drilling etc., are being done by State and private enterprises, involving large capital investments.

One is bound to be impressed by the large annual intake of undergraduate and graduate students from universities for summer employment by the Federal and State agencies and large mining companies and smelters. This not only provides practical training to the students but also solves the problem of recruitment to Government service and in the industries.

II. UNITED STATES GEOLOGICAL SURVEY

The U. S. Geological Survey with over 75 years of service (1879-1957) to the country has some 8,000 employees including about 3,000 scientific or technical personnel, out of which the number of Geologist is about 800. Generally speaking, the Survey spends about $ 48,000,000 annually in funds from all sources, namely, direct appropriations to the Survey, reimbursements from various Federal agencies, and funds available from States and their political sub-divisions.

Headed by a Director, under the Department of the Interior, the Survey has its headquarters in Washington, D. C , maintains an excellent library, and has four Technical Divisions (Geologic, Conservation, Water Resources and Topographic) and an Administrative Division. In addition, there are several units at headquarters, such as Publications office (Distribution Branch and Map Reproduction Branch), Texts (Editor-in-charge), Illustrations (Chief Illustrator), office of Chief Counsel, and Staff (Administrative Geologist, Staff Co-ordinator, Staff Engineers, Information Officer, and Chief Inspector). The Administrative Division looks after the administrative management having a Division Chief-in-charge, and has several Branches (Organisation & Management, Budget & Finance, Service & Supply, and Personnel). The Director's pay is $ 18,000 per annum. The Technical Division Chiefs get a salary of about $ 12,000 per annum. The Branch Chiefs are paid an annual salary of $ 10,000.

The Geologic Division is headed by a Chief Geologist, and has several major Branches such as (1) Mineral Deposits, (2) Fuels, (3) Engineering Geology (headquarters at Denver), (4) General Geology (heardquarters at Denver), (5) Geophysics, (6) Geochemistry & Petrology, (7) Alaskan Geology, (8) Foreign Geology, (9) Palaeontology & Stratigraphy, and (10) Military Geology. The Division maintains several field offices.

The Conservation Division is headed by a Chief Engineer, and is meant for classifying Federal lands as to mineral and water resources, supervising mining leases, permits, licenses and oil and gas development in Federal lands and Indian reservations, and assuring safe and economical production of coal, oil, gas and other minerals. The various branches are (1) Mineral Classification, (2) Water & Power, (3) Mining, and (4) oil & Gas Leasing. The 'Division maintains about 45 field offices.

The Water Resources Division is headed by a Chief Hydraulic Engineer, and appraises the Nation's surface and underground water potentialities. The various branches are (1) Technical Co-ordination, (2) Program Control, (3) Surface Water, 4) Ground water, and (5) Quality of Water. The Division has about 100 field offices and several field stations.

The Topographic Division is headed by a Chief Topographic Engineer, and has several Branches such as (1) Plans & Co-ordinations, (2) Research & Technical Control, (3) Atlantic Region (headquarters at Arlington, Va.), (4) Central Region (headquarters at Rolla, Mo.), (5) Rocky Mountain Region (headquarters at Denver), and (6) Pacific Region (headquarters at Sacramento, Calif.). The Division has published to date some 17,000 topographic maps of various scales, comprising 73% of the continental United States. Maps are also prepared by aerial photography by contracts. The Division has six field offices, and map revision is undertaken in all territories and possessions of the United States.

Geologic Division :—The recruitment to the Survey is done through the Civil Service Commission, but the U. S. Geological Survey is delegated power to select candidates through an Examining Board who conduct examinations and take into account the experience of the candidates. The questions are generally of multiple choice types (yes or no for answers) and also include essay type ones to test the writing capacity of the candidates.

The initial pay of geology graduates and fresh recruits in the Geological Survey is about $ 4,500 per annum, rising up to $ 8,000 scale in stages.

University Professors can get part-time employment in various projects, and the scale of remuneration is determined by their status and experience.

Every year a number of geology graduates are employed during the summer as Field Assistants, and they are usually paid at the rate of $ 3,800 per annum. At times 100 such students are employed on this basis.

Scale of geological mapping is usually 1" = 1 mile, but in mining areas 2½" = 1 mile scale (1 : 24,000) is followed. Detailed mapping in mining districts is generally carried out on 40 ft. = 1 inch scale.

The field season is usually in summer months and covers 3 to 4 months on an average. In south-west (Arizona, New Mexico, etc.) the work is spread between November and December and again between March and April. All exploratory drilling undertaken to prove deposits is done by contracts.

The publications of the U. S. Geological Survey are as follows :— Professional Papers, Bulletins, Water Supply Papers, Circulars, Annual Reports, Mineral Resources (being published by the U. S. Bureau of Mines since 1925), Miscellaneous Reports, Geological Maps, Mineral Resources Maps & Charts (include geological investigation maps), Hydrologic Atlases and Topographic Maps.

The U. S. Geological Survey's contribution to meet the Nation's ever increasing needs for new finds of raw materials could be gauged from the innumerable projects on topographic and geologic mapping, investigations of mineral deposits, assessing surface and underground water resources, administering mineral leasing laws, developing improved and new techniques for mineral exploration, etc. In co-ordination with the U. S. Bureau of Mines, the U. S. Geological Survey gives valuable contribution to implement the projects of the Defence Minerals Exploration Administration and the Emergency Procurement Service. In late years the Survey has been undertaking large scale investigations of fissionable raw materials for the AEC, in the field of pure geology and long range problems, but the production geology is carried out by the AEC. The Survey in recent years has been assisting in the development of mineral resources in several under-developed countries under the Mutual Security Act. It also advises the National Security Resources Board the National Science Foundation, the Office of Defence Mobilisation, and the Department of Defence. Of late, the Survey's achievements have been noticed in successful development and use of airborne magnetometers, airborne radioactivity methods, geochemical exploration methods, photogeologic techniques, etc. In 1955, some 70,000 air miles were flown in connection with airborne magnetic and radioactivity surveys.

The Military Geology Branch offers technical advice to the Military Engineers on various aspects of geology in the U. S. A. and in foreign countries. Mineral investigations in Latin America, Asia and Africa are undertaken by the Foreign Geology Branch in co-operation with the Foreign Operations Administration, the AEC and the Emergency Procurement Service. This Branch also assists the foreign countries in the appraisal of their mineral potentialities by offering services of their personnel on short or long term basis,

The Denver Branch office of the U. S. Geological Survey have over 800 employees and houses, numerous well equipped Laboratories and Sections, such as (1) Engineering Geology, (2) Geochemical Exploration (including mobile Laboratory units), (3) Mineralogical & X-Ray, (4) Palaeontology & Stratigraphy, (5) Petroleum Geology, (6) Physical Properties, (7) Radiometric & Radiochemical, (8) Radiation, (9) Raw Materials, (10) Rock Analysis, (11) Sample Preparation & Equipment, (12) Sedimentation, (13) Photogeology, etc.

III. UNITED STATES BUREAU OF MINES

The total funds available to the Bureau of Mines in 1954 was of the order of 38.8 million dollars, the number of employees being about 5,000.

The Bureau's problems pertain to (1) **Minerals and Metal Technology**—to ensure adequate supply of critical or strategic minerals by assisting the mining industries to adopt better production and utilization of domestic mineral resources, (2) **Fuels Technology**—to ensure adequate supplies of fuels, to prevent wastes, and to encourage utilization of uneconomic fuel resources, consistent with national security and economic development (3) **Explosives Technology**—to minimise explosion hazards of dusts, fumes and gases, and to determine the effectiveness of explosives from the view point of safety and improved mining techniques, (4) **Helium**—to ensure its adequate supplies to military and civilian requirements by undertaking helium production, distribution and transportation and research projects, (5) **Health and Safety**—in the mineral industries, and (6) **Economics and Statistics**—to make statistical study of mineral reserves, production, distribution and consumption of both domestic and foreign sources, to assist Government in determining mineral policies and programmes, and to provide industry with basic data for future development

The headquarters organisation of the Bureau consists of (1) Office of the Director (Director, Deputy Director, Executive Assistant for Regional Activities, and Chief, Office of Mineral Reports), (2) Office of the Assistant Director—Programmes, with Technical Appraisal staff (Chief Mining Engineer, Chief Metallurgist, Chief Coal Technologist, Chief Petroleum Engineer, Chief Economist, and Chief Statistician), (3) Chief, Division of Administration (Branches : Finance, Personnel, Property management and office services), (4) Chief, Division of Minerals (Branches : Base Metals, Ferrous Metals and Ferroalloys, Light Metals, Rare and Precious Metals Construction and Chemical Materials, and Ceramic and Fertilizer Materials), (5) Chief, Division of Bituminous Coal (Branches : Bituminous Coal Research, Explosives, Air and Stream Pollution, and Bituminous Coal Economics and Statistics), (6) Chief, Division of Anthracite (Branch : Anthracite Experiment Station, Schuylkill Haven, Pa), (7) Chief, Division of Petroleum (Branches : Petroleum Production, petroleum Chemistry and Refining, Petroleum Economics and Oil Shale), (8) Chief, Division of Foreign Activities, (9) Office of the Assistant Director, Health and Safety (Chief, Division of Coal Mine Inspection, Chief, Division of Health, and Chief, Division of Safety), and (10) Helium Activity (Washington Liaison Office).

The field organisation of the Bureau comprises five regions of field activities pertaining to fuels and minerals technology and industry studies, exclusive of anthracite, health and safety, and helium activities, each under a Regional Director.

Recent work of the Bureau included (1) determination of extent and nature of submarginal deposits and development of methods for their utilization, (2) development of new superior alloys, (3) synthesizing deficient strategic minerals, (4) research on mining, preparation, carbonization and combustion of coal, (5) increment in ultimate recovery of petroleum and better refining, storage and utilization of oil, (6) methods of extracting liquid and gaseous fuels from coal and oil shale, (7) air-pollution studies, etc.

The Bureau actively co-operates with the U. S. Geological Survey, the office of Mineral Mobilization, the Defence Minerals Exploration Administration Programme, and with other scientific and research organisations of the country. In 1956, the Bureau, under a contract with the AEC, analysed over 24,000 samples sent by the public and reported to be radioactive.

It is realised that there is an increasing need for helium, a valuable inert inflammable gas, and that steps should be taken to offset the waste in the large amount of helium bearing natural gas used for domestic and other uses without undergoing any helium recovery processes.

The Bureau's most important publication is the annual Minerals Yearbook. It is of great value to the public, industrialists and the Government Departments concerned with mineral industry and trade. It deals with all aspects of the mineral industry and provides vital statistical data. Other publications include Bulletins, Information Circulars, Handbooks, Reports of Investigations, Miscellaneous Reports, etc. The Bureau maintains a library of industrially sponsored technical-educational films for free loans to interested institutions or organisations.

In 1956, out of total funds of $49,895,064 available to the Bureau of mines, the obligations incurred amounted to $ 31,942,256. Funds available to the Bureau include direct appropriations, prior balance available, reimbursements, advances and transfers from other Government agencies, proceeds from helium operations, and contribution from non-Government sources. The Bureau has a total staff of over 4,000 paid employees in addition to large number of part-time employees like scientific personnel from universities and industry, students trainees and assistants, foreign trainees, etc.

The foreign activities of the Bureau mainly comprise (1) evaluation of foreign mineral deposits, and collection of data on their development and metallurgical problems, giving wide publicity, (2) technical assistance to underdeveloped countries in co-operation with the International Co-operation Administration, by sending specialists to undertake projects in foreign countries, (3) offering foreign trainees technical training in its Laboratories, (4) services to foreign Governments in the form of supplying mineral information and advice, and (5) supply of information and advice to industry on foreign mineral matters, which encourages participation by American capital in development of mineral resources abroad. The foreign activities ensure continued import of various strategic minerals in which the country is either deficient or poor.

IV. STATE GEOLOGICAL SURVEYS AND DIVISIONS OF MINES

Illinois State Geological Survey—With the exception of Massachusetts, all States have independent State Geological Surveys of various denominations. Some have large organisation whereas others are very small units. The Illinois State

Geological Survey ranks as one of the most reputed and large organisations of its kind in the U. S. A.

Directly under the Department of Registration and Education, the Illinois State Geological Survey is directed and controlled by the Board of Natural Resources and Conservation, and is housed in the Natural Resources Building, on the university of Illinois campus. This Board is constituted of scientists of high calibre, appoints all technical staff without reference to the State Civil Service, and approves the budgets and programmes of the Geological Survey, the Natural History and the Water Survey.

Headed by a chief, the Department has a technical staff of about 90 and has several important Divisions, e. g., Geological Resources, Geochemistry, Mineral Economics, etc. The Survey maintain a very good library. Its publications include Maps, Bulletins, Reports of Investigations, Illinois Petroleum Series, Circulars and Miscellaneous Reports. The data are freely made available to the public and the industry. The Survey carries out basic field and laboratory work and provides accurate information on the State's known and potential mineral resources. It also collects, studies and co-ordinates all records of wells drilled through the State of Illinois. There are about 40 Laboratories equipped with up-to-date scientific apparatus for Geological, chemical and physical research, including X-ray spectrography. The Department also maintains close relationship with the industry in order to keep in touch with its needs and with modern technical developments.

The Geological Resources Division has several sections, each in charge of a specialist. The sections are Coal, Oil and Gas, Petroleum Engineering, Industrial Minerals, Clay Resources & Clay Mineral Technology, Groundwater Geology & Geophysical Exploration, Engineering Geology & Topographic Mapping, and Stratigraphy & Aerial Geology. The Geochemistry Division has the following Sections ;-Coal Chemistry, Physical Chemistry, Fluorine Chemistry, X-ray, Chemical Engineering, Spectrochemistry and Analytical Chemistry. The Mineral Economics Division collects and co-ordinates all data as relevant to mineral statistics.

Topographic mapping in Illinois is done as a co-operative project by the U.S. Geological Survey and the State Geological Survey, the cost of map making being borne on 50-50 basis. The maps, however, are actually prepared and printed by the U. S. Geological Survey.

The mineral production in Illinois consists of coal, petroleum, natural gas, stone, silica sand, lime, cement, clay products, sand gravel, fluorspar, and metals. The value of mineral production in 1955 was of the order of $ 592,492,000. The State is the Nation's leading producer in fluorspar which is finding varied new uses including the manufacture of refrigerants, insecticides, aviation gasoline, fluorocarbon plastics, in the development of atomic energy, etc., apart from other long-standing uses in the steel industry, in ceramics, in acid manufacture, as a fluxing agent to supplement or replace natural cryolite, etc. In 1955 altogether 55,922 wells were drilled in Illinois State for oil and gas ; 63% were oil or gas producers whereas the rest were dry holes.

Division of Mines, California.—The most important State Divisions of Mines or Geological Surveys are located in Illinois, California, Ohio, Pennsylvania, Indiana, New Mexico and Nevada.

The California Division of Mines, with headquarters at San Francisco is a part of the Department of Natural Resources, State of California, which also includes the Division of Oil and Gas and the Department of Water Resources. The Division of Mines has a technical personnel of 33 and is headed by a Chief and a Deputy Chief. The Division maintains three branch offices at Los Angeles, Sacramento and Redding.

The Division has four major phases or areas of Division work, each under the charge of a Senior Mining Geologist, as follows :—

(1) Mining Engineering.—Inventory of mineral resources by countries, mineral utilization surveys, and management of Division business.

(2) Technical Information Service.—Mining activities, mineral economics and statistics, and Library.

(3) Mineralogy, Petrology, Laboratory, and Exhibits.

(4) Geologic and Commodity Surveys.—Quadrangle and State mapping.

The Division carries out its programme in co-operation with other State and Federal agencies like the U. S. Geological Survey and the U. S. Bureau of Mines, on mining, exploration, geology, engineering, water development, etc. It also issues ore buyers' licenses, as it is unlawful for any person to engage in the business of milling, sampling, concentrating, reducing, refining, purchasing, or receiving for sale, ores, concentrates, etc., without first producing a proper license. The investigation of illegal transactions is carried out in co-operation with local, State and Federal authorities The services rendered by the Technical Information Service of the Division include provision of data on basic geology, raw material sources, production and mineral processing, physical and chemical data on rocks and minerals, marketing, mineral utilization mining docoments and law, etc. The Division makes the literate public more mineral minded, provides speakers on the geology and mineral resources of California, conducts field trips, exhibits documentary films on mineral industry, and undertakes mineral fairs and shows. The important publications are (1) California Journal of Mines and Geology - a quarterly publication, (2) Bulletins, (3) Special Reports, and (4) Mineral Information Service—a monthly news release to inform the public of the discoveries, operations, markets, statistics and new publications, pertaining to mineral resources and industry of California.

The mapping programme is undertaken partly by officers of the Division, and partly by university Professors and graduate students, private professional geologists of exploration companies, and members of the U.S. Geological Survey.

Particular mention may be made of the recent nickeliferous laterite survey of the Division, the mapping programme of which was responsible for the discovery of a low-grade nickel ore in the laterite in the Klamath Mountains. Work has proved that such laterite formed due to residual enrichment of nickel in laterite, a type of soil developed from serpentine as a result of intensive chemical alteration, is widely located on early Tertiary erosion surfaces in the Klamath Mountains and foot-hills of the Sierra Nevada. Commercial deposit, however, has been located so far in Del Norte county.

Of late there has been an increasing demand for raw materials to the industries in the State, and the Division is playing an important role in assisting such industrial growth. In 1954, the total value of mineral production in California amounted to $ 1,420,859,359. Petroleum topped the list of all commodities, followed by natural gas, cement, sand and gravel, boron minerals, stone (miscellaneous), tungsten ore concentrates, iron-ore, gold, salt and clay.

V. GEOLOGICAL-MINING EDUCATION AND RESEARCH

There are many universities teaching geology[1] and offering degrees, the top ranking ones being Harvard, Johns Hopkins (Baltimore), Stanford, Princeton, California Institute of Technology and Yale. Geophysics is taught in Stanford, Colorado School of Mines, California Institute of Technology, Berkeley and Harvard The Massachusetts Institute of Technology al o offers training in geology and geophysics.

B. S. degree course is of 4 years duration, whereas M. S. takes one to two years after B. S. One can go straight for Ph. D., 3-4 years after B. S , instead of doing M. S.

Petroleum Engineering course (B. S.) is given in the Colorado School of Mines and Montana School of Mines, and in the universities of Illinois, Missouri, Oklahama, Stanford, Texas, etc.

The Mining Schools give B. S. degree on 4-5 years' course. There are several Mining Schools in the U S. A. The important ones are the Colorado School of Mines, the Montana School of Mines, the Michigan College of Mining and Technology, the Missouri School of Mines & Metallurgy. The Stanford and Utah universities also offer both B. S. (4-5 years) and M. S (1-2 years) degrees in mining. Ph. D. in mining is also given in these two universities.

Large funds are made available by the industry for research in the universities and technical institutions, where eminent Professors and research workers are attached, and thereby the standard of teaching is decidedly of a high order. Throughout the U S. A , there is active co-operation between the Federal and and State Laboratories and the mineral industry in promoting research work. The large exploration and mining companies have their own up-to-date research Laboratories. Their work is mostly connected with exploration of minerals, milling, smelting, refining, etc.

Colorado School of Mines.—The Colorado School of Mines, the oldest institution in the United States devoted exclusively to the training of Engineers for the mineral industries, ranks as one of the world's most important Institute of its kind. The School is within easy reach of important Au-Ag-Pb-Zn-Mo minerals, coal fields, oil fields, etc., thus offering the students easy access to various types of mineral deposits. The main campus of the School covers over 20 modern, well equipped buildings.

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[1] "Directory of Geology Departments of educational institutions in the United States and Canada", published by the American Association of Petroleum Geologists in 1949, gives valuable information. A similar and up-to-date Directory was issued by the American Geological Institute (Report No. 8) in 1952.

The School maintains an experimental mine near Idaho Springs, which provides facilities for research and studies in practical Mining Engineering. The Geology and Geophysics field camp in Wild Horse Park, with an area of over 15,000 acres, is the second field camp, offering much scope for field geology and geophysics. The third field camp at Rangely, in the Rangely oil field, provides valuable opportunities to the Petroleum Engineering and Petroleum Refining Engineering students.

The undergraduate course leads to degrees of Geological Engineer, Geophysical Engineer, Metallurgical Engineer, Engineer of Mines, Petroleum Engineer, Petroleum Refining Engineer, etc. The graduate course leads to degrees of M. Sc. and D. Sc. The professional training thus covers the fields of mining geology, petroleum geology, mining geophysics, petroleum geophysics, metallurgy, coal mining, metal mining, petroleum production and petroleum refining.

There are over 1,000 students on the roll, inclusive of about 100 foreign students representing 40 Nations. The teaching staff in geology consists of 22 persons (Professors, Assistant Professors and Instructors). The Geophysics Department has all ground types of magnetometers, electrical equipment, gravitymeters (mobile and hand portable), a torsion balance, and a 12-channel, wide-range, reflection-refraction seismograph with magnetic recording together with ancillary equipment to carry out full scale seismic prospecting. The Geophysics Department has a staff of 4 (Professor, Assistant Professors and Instructors). The Mining Department has altogether a staff of 6 (Professor, Associate Professors and instructors).

Kenncott Research Centre.—Both fundamental and applied researches are being carried out at the newly built Research Centre on the university of Utah campus. The research pertains to mining, milling, smelting and refining problems of the Kenncott Corporation's four western mining divisions in Arizona, Nevada, New Mexico and Utah. There is well equipped Analytical Microscopic Laboratory, a Ore Dressing Laboratory, an Extractive Metallurgy Laboratory, and a pilot plant where research projects are tested for commercial application. The Infra-red Spectrophotometer can determine the composition of a compound in 15 minutes and the development of X-Ray Diffraction Fluorescence techniques enables scanning a sample for complete qualitative analysis in 45 minutes or quantitative determination of a specific element in 5 minutes.

Research at Climax.—At the newly set up Mill Laboratory at Climax, problems on the recovery of molybdenite, tungsten, pyrite and tin are handled. The Climax Molybdenum Co. also sponsors outside research investigations in cooperation with the Colorado School of Mines Research Foundation, the Denver Research Institute (University of Denver), the Pennsylvania State University, the

Massachusetts Institute of Technology, American Cyanamid Co., of the South-western Engineering Co., and the Hall Laboratories Inc.

Technical & Learned Societies.—They also stimulate research by publishing the results of current research projects. Some of the larger societies pertaining to geology and mining are as follows :—

(1) American Association of Petroleum Geologists.
(2) Society of Economic Geologists.
(3) Geological Society of America.
(4) Society of Economic Palaeontologists and Mineralogists.
(5) American Geophysical Union.
(6) Society of Exploration Geophysicists.
(7) Mineralogical Society of America.
(8) Mining and Metallurgical Society of America.
(9) American Institute of Mining & Metallurgical Engineers.

VI. GEOPHYSICAL RESEARCH AND EXPLORATION

The geophysical prospecting methods employed in the U. S. A. include magnetic, electrical, gravitational, seismic and radioactive methods. Those methods are widely used for the search of oil and gas, and exploration companies carry out airborne and ground geological surveys for location of metallic ore deposits

Programmes of geophysical research are being persued by the U. S. Geological Survey, the State agencies, universities, oil companies and several exploration companies. The Research projects cover various fields of geological studies using geophysical tools and exploration methods, i. e., seismic exploration, gravity exploration, magnetic prospecting, and electrical and electromagnetic prospecting.

Fundamental geophysical research activities sponsored at universities have an important bearing on the exploration geophysics, and may lead to new or improved methods of prospecting for oil and minerals. This can be gauged from the interest shown by large number of oil companies, geophysical exploration companies, logging companies, etc., in offering research grants, fellowships and equipment, in various American universities (e. g., Massachusetts Institute of Technology, university of California, etc.). It is stated that the American Petroleum Institute grant for 1957-58 for several universities will amount to $ 30,000.

The important research centres are located in Massachusetts Institute of Technology ; university of California ; Carnegie Institution, Washington ; Lamont Geological observatory ; Pennsylvania State university ; St. Louis university ; Utah university ; Stanford university ; California Institute of Technology, etc.

During recent years, Applied Geophysics has played an important role in the economy of the U. S. A., in the search for oil and minerals. Judging from the diversity of geophysical explorations, the magnitude of work, the amount of money spent annually for such work etc., as would be evident from the recent trends of mining industry and oil exploration, one is apt to believe that the U. S. A. is one of the leading countries of the world in the field of geophysical exploration.

The recent technique of reflection seismology has been successfully employed for mapping sub-surface structures relating to oil accumulation. The use of gravimeter and airborne magnetometer has been on the increase due to high cost of seismic operations. In the field of metallic mineral exploration, the recent emphasis has been on the airborne magnetometer, airborne scintillometer and in electromagnetic methods.

Recent developments in exploration geophysics in oil exploration include work on magnetic recording, instrumentation for water work, seismic developments, bore-hole geophysics, etc. Academical research work in recent years pertain to (1) industry supported research on prospecting fundamentals, (2) shot-hole explosion studies, (3) use of geophysics in regional studies, (4) mechanics of faulting, and (5) paleomagnetism.

There are several manufacturers of geophysical instruments in the U. S. A. Such equipment is manufactured at Houston by the Houston Technical Laboratories and the South-Western Industrial Electronics.

VII. MINERAL RESOURCES

The geology of the U. S. A. is very varied and complex. A glance at the geological map of the United States (U. S. Geological Survey, 1932), on scale of one inch to 40 miles, in four sheets, will show that practically all the main geological formations are represented as follows :—

Pre-Cambrian. Pre-Cambrian (Archaean and Algonkian) older gneisses and schists, volcanic rocks, intrusive rocks, older igneous rocks, etc.

Palaeozoics.—The Palaeozoics comprise Cambrian to Permian.

Mesozoics.—The Mesozoics comprise Triassic to Cretaceous rocks, including some intrusives and extrusives.

Tertiary.—The Tertiary rocks comprise Eocene to Pliocene formations with intrusive and volcanic rocks.

Quaternary.—This includes marine limestone, alluvium, coastal and estuarine sand and gravel, lake deposits, wind blown sand, glacial drift, Recent and Pleistocene volcanic rocks, etc.

The United States is endowed with large mineral resources as would be evident from a large variety of minerals in great abundance. However, no country is fully self-sufficient in mineral resources due to an uneven distribution of minerals in the world. The U. S. A., although rich in many essential minerals, lacks in many strategic minerals.

During World War II, the U. S. A. had to import some sixtyfive different minerals, from fifty-three countries, twenty-seven originating from entirely foreign sources. The post-war demand for minerals in the State is equally great and is anticipated to be greater in the next 25 years. It has been recently estimated that out of 41 minerals required for industry and defence, 15 will last for half a century, 3 for 33-40 years, 20 for less than 25 years and 9 for less than 10 years. With regard to 8, no reserves are available. It is stated that the country's deficiencies will have to be largely met from imports from British Commonwealth, overseas areas of France, Belgium and Holland, Europe and Latin America.

There has been a considerable drain on the resources of the country, consequent upon increase in annual rates of consumption since World War I, particularly during World War II. In 1945, the U. S. Geological Survey and the U. S. Bureau of Mines made an exhaustive study of the mineral position of the country, and the data were published in 1948. The following tables taken from "Mineral Resources of the United States", Public Affairs Press, Washington, D. C., 1948, sum up the U. S. mineral position (relative self-sufficiency) in a general way :—

Actual and Impending

(Based on present technologic and economic conditions and on known "commercial reserves")

A. **Virtual Self-sufficiency Assured for a Long Time.**—Bituminous coal and lignite, Anthracite, Natural gas, Magnesium, Molybdenum, Fluorspar (metallurgical), Helium, Magnesite, Nitrates, Phosphate rock, Potash, Salt, Sulfur.

B. **Complete or Virtual Dependence on Foreign Sources.**—1. Small or remote expectation of improving position through discovery :—
Chromite, Ferro-grade manganese, Nickel, Platinum metals, Tin, Industrial diamonds, Quartz crystals, Asbestos (spinning quality).
2. Good expectation of improving position through discovery :—
Cobalt, Graphite (flake).

C. **Partial Dependence on Foreign Sources, Actual or Impending.**—1. Good expectation, Arsenic*, Bismuth*, Copper, Iron ore, Lead, Mercury, Tantalum*, Titanium, Tungsten, Zinc, Fluorspar (acid-grade),
2. Little hope of improving position through discovery :—
Antimony*, Vanadium, High-grade bauxite, Strategic mica.

(Potential)

(If technologic and economic changes permit use of known submarginal resources)

A. **Virtual Self-sufficiency.**—Bituminous coal and lignite, Anthracite, Natural gas, Petroleum, Aluminium ores, Copper, Iron ore, Magnesium, Manganese, Molybdenum, Titanium, Vanadium, Fluorspar (all grades), Graphite (Flake), Helium, Magnesite, Nitrates, Phosphate rock, Potash, Salt, Sulfur.

B. **Complete or Virtual Dependence on Foreign Sources .**—Platinum metals, Tin, Industrial diamonds, Quartz crystal, Asbestos (spinning quality)

C. **Partial Dependence on Foreign Sources.**—Antimony, Arsenic, Bismuth, Cadmium, Cobalt, Chromite, Lead, Mercury, Nickel, Tantalum, Tungsten, Zinc, Strategic mica.

Constant and diligent search is being made in the U. S. A. for new sources of minerals, by geologic, geophysical, geochemical and exploration methods, both by Government agencies and private organisations. However, experts believe that there is a necessity for a co-ordinated long-term programme of research and exploration, on a national basis.

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*Domestic production chiefly by-product

The U.-S. A. has made remarkable progress in mining technology in recent years in the field of exploration, explosives fragmentation, drilling techniques, mechanical fragmentation, and improvements on loading, transportation, hoisting, etc. The emphasis is on exploitation of leaner ores and ores at greater depths, in view of decreasing reserves of high-grade ore and exhaustion of shallow deposits. Researches in mining technology are carried out by Government agencies, universities and larger mining concerns. The oil industry has made great progress in the field of secondary recovery of oil through water flooding, thus increasing the oil potentialities of the country.

The U. S. A. has also made great achievements in the field of milling, recovery of by products and metallurgical problems, as would be evident for exploitation of submarginal ores, and yet many new problems in the treatment trends will have to be faced and solved to attain self-sufficiency in various minerals.

The restriction on the export of Indian ilmenite acted as an impetus to the development of new titanium deposits of Florida. Similarly, with a view to maintaining an adequate supply of manganese to offset the uncertainties of Indian manganese-ore, some U. S. A. firms are developing the Brazilian sources.

VIII. EXPLORATION OF MINERALS

In this Chapter the activities of the following mining centres are briefly dealt with :—

(1) Climax Molybdenum Mine.
(2) Bingham Copper Mine.
(3) Butte Copper Mines.
(4) Bunker Hill Pb-Zn Mine.
(5) Oil fields in Los Angeles Basin.

Climax Molybdenum Mine.—The molybdenum Mine, with an average daily output of over 28,000 tons of ore, is regarded as North America's largest underground mine. The ore body is in the form of irregular stockworks in Pre-cambrian granites and schists and early Tertiary porphyry intrusives, the mineable portion being 250 to 400 feet in thickness. The intrusives range in composition from quartz monzonite to diorite. The "Mosquito fault" to the west, separating the Palaeozoics from the Pre-cambrian, runs N 10 E and has a displacement of 2,000 to 5,000 feet. The "Major fault" running N 23 W lies to the east of the ore body. Mining is limited between these two faults.

The most important ore is finely disseminated molybdenite in thin veins and stringers of quartz ; some hubnerite (wolframite), pyrite and cassiterite are recovered in addition to topaz. The mineable limits of the ore zone are carefully determined, the stoping limit being 0.4% MoS_2, necessitating some 255,000 feet of diamond drilling Drilling is normally spaced on 200-foot centres initially, with later drilling on 100-foot centres. The mining plan is set up from the ore zone sections as determined by assay, there being no definite structural boundaries limiting the ore body.

The present yield is from the Phillipson (11,463 ft.) and Storke (11,168 ft.) levels, although sub-level mining is undertaken on seven levels between 11,940 ft. and 11,540 ft. The automation for the underground mining is best indicated by the caving and slushing systems, permitting on an average an output of 200 tons of ore per man per shift. Main and loading haulage drifts are driven 15 ft. wide x 13 ft. high when timber is used and 13 ft. x 11 ft. in unsupported areas. The large headings are made by a two-machine hydraulic jumbo mounting 3½-inch drifters. Large air-operated rocker-loaders dump directly into the 200-cu. ft. Granby haulage cars. Drifts vary in length from 112 to 145 feet, but spacing between them is about 68 feet. The most important phases of the operations are the design of the slusher drifts and the operation of the slushing equipment. There are over 25 miles of mine workings.

The present milling capacity at climax is 28,000 tons per day. The average composition of ore is 0.5% MoS_2. After passing through three stages of crushing the ore is fed to nine-foot diameter ball mills. A special classifier separates the coarse material from the fine, re-cycling the former to the mill for further reduction. Fines are treated at the flotation section. The rough concentrate containing 8-10% MoS_2 is thickened and cleaned in four stages of flotation with grinding and classification between each stage. The final concentrate containing 90% MoS_2 is filtered, dried and despatched to customer. Finely ground tailings from the cleaning plant go to the tailing pond, whereas the coarse tailings from the roucher circuit are the feed to the by-products plant for the recovery of pyrite (50% S), wolfram and cassiterite. Pyrite is separated by flotation and sold for acid manufacture, and the non-float from the pyrite flotation is tabled for the recovery of wolfram and cassiterite. Wolfram is separated by magnetic separator, the concentrate containing 65%-68% WO_3. The non-magnetic portion containing cassiterite is upgraded by tabling or screening to 35% Sn. The MoS_2 concentrate is sent to the Climax's processing plant at Langeloth, Pa. for smelting and refining, the plant being the world's largest molybdenum processing installation.

Bingham Copper Mine. - Located 30 miles south-west of Salt Lake City, Utah, the Bingham copper mine, the largest opencast for copper ore in the world, yielding about 22% of the newly mined copper in the U. S. A , is worked by the Kenncott Copper Corporation.

Chalcocite and chalcopyrite occur as disseminations in a monzonite intrusive into quartzite and limestone (Pennsylvanian), the ore containing less than 1% Cu (0 82% Cu), small amounts of Mo (1/20th of 1%), and minute amounts of Au and Ag (1 oz. per ton each). Large scale mechanized mining is economically possible due to large size and uniform mineralisation of the ore body. In the periphery of the monzonite intrusive and in the invaded sedimentary formation, Pb-Zn mineralisation is evident, where several underground mines are being worked for lead and zinc.

The mine is in the form of a large amphitheatre of 1,000 acres, 2,210 feet deep, the sides of which are cut into benches. Altogether there are 22 levels on the west side and 15 on the east side and 13 sub-levels average 50 feet in height and the upper levels 70 feet in height, with a maximum width of 65 feet. Additional levels at 50-foot intervals will follow with further deepening of the opencast. A three mile long haulage tunnel is being driven from the entrance of the Bingham canyon to the bottom of the opencast, and there are already two other tunnels in operation. Roughly two tons of waste rock are to be mined and dumped elsewhere to win one ton of ore. About 90,000 tons of ore are being won daily. 24-foot to 28-foot holes at 15-foot to 20-foot intervals are drilled for breaking ore and waste. Electric shovels load the waste into 40-yard side-dump cars for haulage by electric locomotives. Ore is loaded in 100-ton railway wagons and hauled by electric locomotives for transport to the Arthur and Magna mills at a distance of 16 miles. The mining area has 166 miles of standard gauge track which is being shifted from time to time as necessary.

Both mills have a capacity to handle 40,000 tons of ore daily. The ore is first led into a gyratory crusher which reduces it to a six-inch size. The ore is reduced to $\frac{7}{8}$-inch size in the cone crushers, and then further reduced to a size that will pass through an eight-mesh screen in the 48-inch rolls. The material is eventually led to ball mill batteries to grind into a powdery state. The material is subject to flotation for the recovery of copper mineral concentrate containing 30% Cu, 1½% molybdenite and small amounts of gold and silver. The concentrate is further treated for the recovery of molybdenite by a combination of differential flotation and heat treatment. The molybdenite concentrate contains more than 90% molybdenite, a small per cent. of Cu. and practically no gold or silver. The final copper concentrate after its flotation treatment and separation from molybdenite, containing 30% Cu and small quantities of gold and silver, is transported to the Garfield smelter of the American smelting & Refining Co. After smelting, the metal is cast into copper anodes containing more than 99% Cu.

The metal is refined at the electrolytic refinery near Magna to yield 99. 96% pure copper. An electrolytic action transfers copper from the anodes to the cathodes, and the anode mud is further treated for the recovery of precious metals and other by-products including selenium. The refinery refines about 16,000 tons of copper per month.

Butte Copper Mines.—Operated by the Anaconda Co., one of the world's largest producers of copper and zinc, the Butte mines lie on a mineralised zone, running eight miles E.-W. and four miles N.-S., the present operation covering some 35% of the area. The ore bodies consist of irregular fissure fillings, generally striking in two or three directions in the Boulder granite which is late Cretaceous to early Tertiary in age. Copper ores occur in the centre of mineralised zone in the form of a dome (practically no Zn), with a zone of zinc ores around (practically no Cu), which in turn is surrounded by a manganiferous zone (primarily Mn with little Zn and Pb). The mineralisation is attributed to the granite, and it is believed that copper ores were formed first, followed by zinc ores and then by maganiferous ores.

The ore bodies have been displaced from a few feet to 300 feet and persist up to the depth mined (about 5,000 feet).

The copper ores consist of chalcocite, chalcopyrite, and enargite. The chief zinc mineral is sphalerite. Manganese occurs chiefly as rhodochrosite and some rhodonite and pyrolusite. Silver is found in traces in all types of ores. The gangue consists of quartz, pyrite and altered granite. Copper ore reserves of the Greater Butte Project, above 3,400-foot level, and of the Berkeley pit, are of the order of 180 million tons and 100 million tons respectively. The zinc ore reserves are estimated at 6.3 million tons.

The company has a compliment of 16 Geologists. Underground mapping is done on 40-foot scale and reduced to 50-foot and 100-foot scales. About 100 technical students work for three months in summer, on wage basis, in chemical and metallurgical works. There are research facilities in Metallurgy.

Present mining methods include underground vein mining, underground block cave mining and opencast mining. The Kelley mine yields some 15,000 tons of ore daily by block caving method. The output from the open pit at Berkeley is about 17,500 tons daily. The important copper mines are the Mountain Con, Leonard, Belmount, Kelley and Steward. The zinc Mines comprise the Anselmo (only working at present ; 3,600 feet deep), Badger, Orphan Girl, Lexington and Alice. The manganese mines are the Emma (only working at present ; 1,600 feet deep), Travona and Niagara. Altogether there are some 2,550 miles of underground drifts, cross-cuts, raises and winzes, and some 45 miles are added annually to the underground workings. The shafts are a few hundred to some 5,000 feet deep (Mountain Con ; 4,955 feet deep). The mines are mostly equipped with electric hoists, and underground haulage of ore is done by electric storage battery locomotives and trolley motors which draw trains of automatic side dumping cars. The shafts in the larger vein mines have four compartments. The stoping width in the vein mines varies from 4 to 50 feet, the stoped out areas being filled by waste rock or tailings.

The average thickness of overburden (zone of oxidation) at the Berkeley pit is 250 feet, and its perimeter when completed will be 4,600 feet by 2,600 feet, and the deepest point will be 490 feet below the elevation of the Meaderville road. A giant crusher is being installed, and the crushed ore will move down a raise into a conveyor belt tunnel.

Located about 26 miles from the Butte mines, the Anaconda Reduction Works now rank as one of the largest of its kind in the world. The copper ore (4 5% Cu in underground mines and 0 80 to 1.1% Cu in surface workings) from Butte is brought by open hopper railroad cars, crushed first in the gyratory crusher, followed by further crushing in the Symons crusher to 1½-inch size. The ore is ground fine by a system of rod mills, classifiers and ball mills, and is concentrated by flotation. The copper tailings contain 0.15 to 0.16% Cu. The concentrates (30% Cu) after thickening and filtering go to the roasters and are smelted in the reverberatory furnaces to produce matte and slag The matte is sent to the converters for further processing. The copper is then taken to the casting furnaces where the impurities are removed and the copper cast into anodes. The anodes are treated at the electrolytic copper refinery at the Great Falls Reduction Works, 169 miles off Butte.

The zinc ore (6-7% Zn) is crushed and ground to fine particles in rotating drums containing iron balls The material is led to flotation units for the recovery of the concentrates. The tailings contain 0.3 to 0.5% Zn. The concentrates (45-50% Zn) are led to roasters whereby sulphur is eliminated by burning. In the leaching plant, H_2SO_4 is added to the treated concentrates to dissolve the zinc, and the zinc solution after puiification is led to the electrolytic zinc plant for electrolytic separation of zinc. The flue gases from the zinc smelter are recovered for the manufacture of H_2SO_4.

The manganese ores (15% Mn) after crushing and fine grinding are subject to flotation for the removal of zinc and lead content. The residue or tail~~ing~~ from this operation is led to the manganese concentrator where the grade is raised to 38% Mn by further flotation. The manganese concentrate is treated in a kiln at 2,500°F to drive off the CO_2 for raising the grade to 58% Mn, and agglomerates of fine nodules are formed. The manganese nodules are used for the manufacture of ferro-manganese.

The Anaconda Reduction Works also process the phosphate rock (46-47% P_2O_5) from the company's opencast mine at Conda, Idaho. The phosphate rock, after drying and fine grinding, is roasted in gas-fired roasting furnaces for driving off excess organic matter. The material is treated with H_2SO_4 manufactured in the Anaconda H_2SO_4 plants, whereby two products (gypsum and phosphoric acid) are formed. The gypsum is a waste, and the filtrate of phosphoric acid is raised to commercial grade in evaporators. A part of the acid is mixed with roasted phosphate rock and forms treble superphosphate, a commercial fertilizer.

Pyrite is also separated from copper concentrates by further process of flotation. It is roasted for the manufacture of H_2SO_4, and a type of sponge iron is recovered.

The products at Anaconda Reduction Works are as follows :—

Anode copper	...	300 tons daily
Zn (99 99%)	..	350 „ „
Mn nodules and ferro-manganese		250 „ „
H_2SO_4		600 „ „
Superphosphate	...	350 „ „

Bunker Hill Pb-Zn Mine.—Located at Kellog, the Bunker Hill Pb-Zn mine is the largest single lead mine in the U S. A., and also pioduces about 15% of the special high grade zinc in the country It is operated by the Bunker Hill Co. The country rocks consist of highly folded and faulted Pre-Cambrian quartzites, slates, shales and graywackes, the major geological features comprising the Osborn fault, Cate fault, Belt series of rocks and ore bodies. The Cate fault dips 46° south and includes a large part of the ancient and recent workings.

The Bunker Hill Co. has a chief Geologist, an Assistant Chief Geologist and an Exploration Geologist.

The ore bodies consist of some 30 major veins and ore shoots, the noted ones being designated as the Bunker Hill, Steinwinder, Last Chance, March, old Sierra Nevada, etc. The present output is chiefly from the Emery, Truman and Shea veins. Some are predominantly lead and silver veins, whereas others are high in zinc with little lead. The chief ores are essentially galena and sphalerite, but occasionally some chalcopyrite, tetrahedrite, stibnite, etc., are present. The total Pb and Zn metal content is about 10% or more. The mineralisation has been noticed up to the depth mined, some 5,000 feet from the surface, 1,350 feet below sea level. The proved lead-silver reserves are estimated at 2,412 402 tons, representing the best grade ore, about 52% of the total reserves.

The mining methods consist of horizontal cut and fill or vertical cut and fill, with the resulting hole being supported by large timbers put together in a square set pattern. For every two tons of ore removed, an additional one ton of waste is mined to fill the resultant hole. There are 100 miles of cross-cuts and tunnels, three main shafts and ten smaller shafts or raises, all with hoisting facilities. The main hoisting shaft is capable of hoisting 6,000 feet and is designed for a 10-ton pay load or a 20-ton total. On an average, 1,186 gallons of water is pumped per minute from the lower levels. Total air circulated in the ventilation system is 150,000 cu. ft. per minute.

A lead smelter and refinery at Kellog produces about 100,000 tons of lead per year. An electrolytic zinc plant produces about 60,000 tons of zinc per year. The sulphur gases produced at the reduction plants are recovered to yield sulphuric acid, the capacity of the sulphuric acid plant being 100,000 tons per year. The other products include cadmium, antimony, silver and gold.

Lead Smelter Production

Year	Lead (tons)
1956	101,714
1955	90,861
1954	84,591
1953	71,254
1952	59,229
1951	54,315
1950	75,249
1949	44,571
1948	61,002
1947	53,442

Zinc Plant Production

Year	99.99% Bunker hill zinc (tons)	Electrolytic cadmium (lbs)
1956	57,799	467,091
1955	56,625	463,356
1954	47,404	389,353
1953	54,037	521,339
1952	54,340	547,714
1951	54,468	543,867
1950	53,922	589,452
1949	41,854	405,942
1948	42,064	414,463
1947	41,801	387,378

The Bunker hill mill also treats ores ftom various mines of the company or other mining concerns. In fact the Coeur D' Alene mining district has numerous Pb-Zn mines and several milling plants of various sizes. Some of the data collected in the Sydney Pb-Zn mine mill are given below :—

Mill capacity ...	300 tons daily
Ore feed ..	Pb : 4.87% Zn : 10.10% Ag : 2.15 oz per ton
Pb concentrate ...	Pb : 56.58% Zn : 14.91% Ag : 22.16 oz per ton
Zn concentrate ...	Zn : 51.29% Pb : 3.12% Ag : 2.34 oz per ton
Tailings ...	Pb : 0.48% Zn : 0.65% Ag : 0.27 oz per ton
Total recovery of Pb	92.46%
Total recovery of Zn ..	95.07%

Oil Fields in Los Angeles Basin.—The Los Angeles basin comprises a N. W.—S. E. strip, 50 miles long and 20 miles wide, representing a marine embayment prevailing as early as Mid-Miocene, when marine sediments were deposited during most of subsequent Tertiary and Pleistocene period. The thickness of marine Pliocene and Pleistocene sediments in the centre of the basin is at least 10,000 feet. Early Tertiary and late Cretaceous sediments were also laid down in parts of the basin. The basement of the basin consists of metamorphic and igneous rocks, as shown by deep oil wells at the northern and eastern parts of the basin.

The Tertiary and Quaternary sediments were continuously deformed by uplifts, downwarps, faulting and folding, as indicated by the Whittier and Newport-Inglewood fault zones and numerous folds as shown by topographic rises in the lowland areas. The Newport-Inglewood fault zone is recognised by a series of *en echelon* hills, indicating the locations and shapes of folds in which oil has accumulated.

The principal source of oil is the Repetto (Lower Pliocene) formation, whereas the Puento (Middle and Upper Miocene) formation has been the next important producing horizon. The faulted anticlines along the Newport-Inglewood uplift have yielded about 1,600,000,000 barrels of oil. The series of folds from Santa Fe springs to Richfield area in the centre of the basin has produced some 900,000,000 barrels. The yield from the remaining fields is attributed to anticlines, fault traps, and stratigraphic traps near the edges of the basin. The broad arch along the north-east margin of the Palos Verdes hills, which includes the Torrance and Wilmington fields, has produced some 700,000,000 barrels of oil.

There are numerous companies working in the basin, including Texas Co., Superior Oil Co., General Petroleum Corporation, Standard Oil Co., Shell Oil Co., Seaboard Oil Co., J. K. Wehrman Oil Co., Union Oil Co., Richfield Oil Corporation, Ohio Oil Co., Continent Oil Co., Macmillan Petroleum Corporation, etc.

There are about 40 oil fields of various denominations, the important ones being Huntington beach, Inglewood, Long beach, Santa Fe springs, Wilmington etc. The structures of the Huntington beach oil field concern a faulted monocline and a dome. Oil is recovered from several zones in Pliocene and Miocene formations. The deepest oil well is about 10,000 feet deep. Wells tapping the Tideland pool are closely spaced in long rows bordering the north side of the Pacific coast Highway, west of the older fields of Huntington beach. Drilling and servicing equipment is moved from well to well along tracks laid in a continuous concrete mat. The Long beach oil field has produced some 800 million barrels of oil from some 1,300 wells in an area of only 1,400 acres. The average yield of 530,000 barrels per acre is probably the highest of any oil field in the world. The deep holes are about 10,000 to 14,000 feet deep. The structure is a faulted anticline, the formations being Pliocene and Miocene. The Wilmington oil field has the highest annual production rate of all Californian oil fields, yielding some 50 million barrels annually in recent years. There are six producing zones in Miocene and Pliocene formations. The structure is a faulted anticline, the faults acting as barriers to the movement of fluids through the sand, each of the six structural blocks being characterised by oil of a different gravity.

IX. MINERAL INDUSTRY

The great achievements of the U. S. A., in common with other leading industrial countries of the world, have been brought about through the utilization of the country's mineral resources. The following table gives an idea of the progressive mineral development in the country.

Annual value of mineral production in U. S. A.

1880	$ 367,0 0,000
1907	$ 2,000,000,000
1944	$ 8,417,000,000
1945	$ 8,140,000,000
1946	$ 8,859,000,000
1947	$ 9,610,000,000
1948	$ 12,273,000,000
1949	$ 10,580,000,000
1950	$ 11,855,000,000
1951	$ 13,529,000,000
1952	$ 13,392,000,000
1953	$ 14,382,000,000
1954	$ 14,135 000 000

The peak of mineral production during the war years, breaking all past record in the history of the nation, speaks of the country's great enterprise. During World War II, efficient research programmes, mineral procurement programmes (from domestic and foreign source), development of the war-based mineral industries, financing through Government agencies, diversion of resources from domestic civilian needs to the war economy, Government subsidies and wartime statutes, increase of production rates, co-operation between Government and private industries, setting up mineral missions to foreign countries, etc., contributed to the wartime economy of the country.

Some of the wartime subsidies and statutes, designed to stimulate increased mineral production, have been retained in the post-war period, the functions of wartime agencies being taken over by the permanent Government agencies.

Some aspects of the mineral industry in the overall national economy of the U. S. A., namely, domestic production, number of mining firms, foreign trade, national income, investment and defence mobilization, will be dealt with in this Chapter. The data have been taken from the various issues of the "Minerals Year book."

Production.—The following table gives the value of mineral production by mineral group, between 1949 and 1954 :—

TABLE 1.—Value of mineral production in continental United States, 1949-54, by mineral group.

(Million dollars)

Mineral Group	1949	1950	1951	1952	1953	1954	Change in 1954 from 1953 (per cent.)
Metals and nonmetals except fuels :							
Nonmetallic minerals except fuels	1,559	1 822	2,079	2,163	2,337	2,641	+ 13
Metals	1,101	1,351	1,671	1,614	1,796	1,486	— 17
Total	2,660	3,173	3,750	3,777	4,133	4,127	0
Mineral fuels	7,920	8,689	9,779	9,615	10,249	10,008	— 2
Grand total	10,580	11,862	13,529	13,392	14,382	14,135	— 2

Mining Firms.—In 1954, about 38,300 mining and quarrying firms (including fuels) operated in the U. S. A. The following table gives the number of mining and mineral and metal processing firms in the U. S. A. between 1939 and 1947.

TABLE 2.—Number of mining and mineral and metal processing firms in the United States, 1939—47.

	Mining firms				Mineral-and metal-processing firms			
Year	Metal & coal mining	Petroleum & natural gas	Non-metallic mining	Total mining	Metal smelting & refining	Fabricated metal products	Products of petroleum and coal	Stone, clay, and glass products
1939	20,200	10,900	5,000	36,100	3,800	10,500	1,200	7,100
1940	20,100	12,600	5,000	37,700	4,000	10,800	1,300	7,200
1941	21,000	13 600	4,700	39,300	4,200	11,500	1,300	7,500
1942	16,600	14 100	4,500	35,200	4,300	11,700	1,300	7,500
1943	12,500	14,600	4,000	31,100	4,300	11,800	1,200	7,300
1944	11,900	15 200	3,900	31 000	4,500	12,400	1,200	7,200
1945	11,700	15,900	3,700	31,300	5,000	13,700	1,300	7,900
1946	12,200	16,500	4,200	32,900	6,000	16,300	1,400	12,600
1947	13,000	16,800	4,400	34,200	6,200	17,900	1,400	13,100

Foreign Trade—The following table gives the value of minerals and metals imported and exported by the U. S. A., between 1952 and 1954.

TABLE 3.—Value of minerals and metals imported and exported by the United States, 1952-54, by commodity groups and commodities, in thousand dollars.

Group and commodity	Imports for consumption			Exports of domestic merchandise		
	1952	1953	1954	1952	1953	1954
Crude Metallic Minerals						
Iron ore and concentrate	82,903	96,842	119,459	37,404	32,422	24,784
Iron and steel scrap	5,401	5,870	5,949	12,500	11 219	51,612
Manganese	67,758	105,673	77,030	504	552	592
Chromium	38,595	56,102	34,197	73	56	50
Ores of nonferrous metals and concentrates :						
Tungsten	57,062	91,602	76,251	46	31	111
Tin	65,287	83,713	41,725	....	...	...
Copper	60,463	59,939	69,142	495	290	1,309
Zinc	113,785	49,714	54,328	899	759	...
Bauxite (aluminium ore) and concentrate	23,194	29,585	36,289	845	886	666
Lead	33,253	15,391	48,306	288	269	25
Columbium	2,369	6,891	14,191	...	....	1
Nickel	4,995	5,794	5,358	...	....	...
Titanium						
Ilmenite	2 478	5,464	4,993	111	110	78
Rutile	1,729	1,791	1,323			
Cobalt	5,668	4,952	5,576	...	....	...
Molybdenum	41	....	180	6,792	7,308	13,989
Other	7,548	9,134	7,489	531	152	107
Nonferrous metal scrap :						
Aluminium	2,592	8,072	4,675	164	1,476	12,985
Old and scrap copper	2,582	4,018	2,081	3,937	17,199	40,234
Old brass and bronze and clippings	3,765	3,737	1,568	2,360	13,066	38 469
Other, not elsewhere included	8,110	5,536	4,990	2,441	3,130	7,040
Platinum-group metals	11,275	11,827	13,643	...	1	2
Total crude metallic minerals—	600,853	661,647	628,743	69,390	88,926	192,054
Metal (Unwrought)						
Pig iron and sponge iron	20,976	27,958	15,156	752	1,145	872

TABLE 3.—Value of minerals and metals imported and exported by the United States, 1952-54, by commodity groups and commodities, in thousand dollars—contd.

Group and commodity	Imports for consumption			Exports of domestic merchandise		
	1952	1953	1954	1952	1953	1954
Ferroalloys :						
Ferromanganese ..	14,759	27,181	10,903	475	389	615
Ferrochromium ...	4 851	10,398	3,502	519	286	996
Other ...	1,978	2,812	2 142	6,802	2,708	1,780
Copper ..	333,870	362 079	277,981	121,596	70,117	130,625
Tin ..	232,692	187,613	142,504	581	298	467
Aluminium ...	43,505	115,761	83,573	519	937	1,691
Nickel (including scrap) ..	89,450	102,750	124,454	6,527	9,674	
Lead ..	167,505	97,449	70,376	733	490	208
Zinc ...	36,220	50,282	33,987	24,715	4,774	5,532
Cobalt ...	27,304	33,225	35,391	...	...	...
Mercury ...	12,547	13,569	10,784	86	106	183
Other nonferrous base metals	11,334	12,726	9,917	4,599	3,860	8,103
Platinum-group metals, including unworked and partly worked. ..	14,259	27,620	21,641	1,689	1,531	2,955
Total metals	1,011,250	1,071,423	842,311	169,593	96,315	154,027
Total metals and metallic minerals	1,612,103	1,733,070	1,471,054	238,983	185,241	346,081
Crude Nonmetallic Minerals (Except Fuels)						
Diamonds :						
Gems, rough or uncut ...	52,193	57,289	60,001	165	415	410
Industrial ...	51,910	49,598	48,841	21	14	63
Total diamonds ...	104,103	106,887	108,842	186	429	473
Asbestos, crude, washed or ground ...	61,596	59,754	55,857	2,550	540	276
Sodium nitrate ...	27,631	23,268	26,818	528	1,126	1,210
Mica, unmanufactured (including scrap) ...	14,271	14,700	8,335	41	28	79
Fluorspar ...	10,527	11,245	8,962	48	49	50

Group and commodity	Imports for consumption			Exports of domestic merchandise		
	1952	1953	1954	1952	1953	1954
Stone for industrial uses, except dimension ...	4,242	5,370	5,807	517	694	762
Sulfur ...	106	51	58	35,966	36,573	52,524
Phosphates, natural, ground or unground	2,332	2,545	3,081	12,404	18.368	21,169
Clays ...	1,917	2,195	2,485	7,014	7,031	8,350
Other nonmetallic minerals (except fuels) ...	17,295	17,298	19,357	17,091	19,390	19,635
Total crude nonmetallic minerals (except fuels)	244,020	243,313	239,602	76,345	84,228	104,528
Grand total, minerals and metals (except fuels)	1,856,123	1,976,383	1,710,656	315,328	269,469	450,609

National Income.—The national income, originated in the mineral industries in the U. S. A., between 1952 and 1954, is tabulated below :—

TABLE 4.—National income originated in the mineral industries in the United States, 1952-54

(Million dollars)

Industry	1952	1953	1954	Change from 1953 (per cent)
All industries ...	289,537	303,648	299,673	−1
Metal mining ...	721	786	698	−11
Nonmetallic mining & quarrying ...	604	648	697	8
Total mining except fuels ...	1,325	1,434	1,395	−3
Total mining including fuels	5,420	5,616	5,234	−7
Primary metal industries ...	7,852	9,360	7,741	−17
Stone, clay and glass products	2,816	3,033	3,009	−1
	(Per cent)			
All industries ...	100.00	100.00	100.00	
Metal mining ...	.25	.26	.23	
Nonmetallic mining & quarrying	.21	.21	.23	
Total mining except fuels ...	.46	.47	.47	
Total mining including fuels ...	1.87	1.85	1.75	
Primary metal industries	2.71	3.08	2.58	
Stone, clay and glass products ..	.97	1.00	1 00	

Investment.—In 1954, the total expenditures by the mining companies (fuel and nonfuel) on new plant and equipment amounted to $ 975 million. The direct private investments of the U. S. A. in foreign mining and smelting industries in 1954 are given in the following table. Earnings on foreign direct investments in mining and smelting in 1954 amounted to $ 204 million.

TABLE 5.—Direct private investments of the United States in foreign mining and smelting industries, 1954.

(Million dollars; net inflows to the United States, (-)).

Country	Mining & smelting				All industries			
	Book value, beginning of year	Net capital movements	Undistributed earnings of subsidiaries	Book value, end of year	Book value, beginning of year	Net capital movements	Undistributed earnings of subsidiaries	Book value, end of year
Canada	677	85	21	783	5,242	469	215	5,939
Latin American Republics :								
Chile	445	−38		407	657	−28	4	633
Mexico	144	18	−20	142	514	15	−6	523
Peru	170		2	172	268	−13		255
Total	999	18	−15	1,003	6,003	102	121	6,256
Western European countries	30		5	35	2,369	36	197	2,605
Western European dependencies	136	−5	8	105	603	−6	41	600
Union of South Africa	59	9	1	69	212	−12	16	216
All other countries	32	3	8	76	1,869	172	51	2,132
Total, all areas	1,933	110	28	2,071	16,329	761	641	17,748

Defence Mobilization.—Under this sub-head may be discussed the various aspects of Defence Production Act, Domestic Purchase Programmes and Loans, Defence Minerals Exploration Administration, National Strategic Stockpile Programme and Atomic Energy Commission.

Defence Production Act.—By December 31, 1954, the gross transactions certified for purchases and other programmes under the Defence Production Act amounted to $ 8.2 billion. There are five delegate agencies for operation, namely, General Services Administration (GSA), United States Department of the Treasury, United States Department of Agriculture, Export-Import Bank, and Defence Mineral Exploration Administration (Interior).

Domestic Purchase Programmes and Loans.—The commodities delivered under United States Government domestic purchase programmes, 1953-54, are tabulated below. The administering of the domestic purchase programmes is done by the General Services Administration. By July 31, 1954, the total loans for mineral expansion projects amounted to $ 8.6 million.

TABLE 6.—Commodities delivered under United States Government domestic purchase programmes, 1953-54

Commodity	Quantity delivered as of Dec. 31, 1953	Quantity delivered as of Dec. 31, 1954	Authorised total purchases
Tungsten concentrate (thousand short ton units) :—	600	1,460	3,000
Manganese ore (thousand long-ton units) :			
Butte and Phillipsburg depots	429	1,418	6,000
Deming depot	790	2,213	6,000
Wenden depot	2,089	5,821	6,C00
Domestic small producers (carload program)	557	2,276	19,000
Chrome ores and concentrates (long tons)	46,640	77,399	2C0,000
Mica : Block, film, and hand-cobbed (short tons hand-cobbed equivalent)	2,593	4,816	25,000
Beryl (short tons)	145	557	1,500
Asbestos, chrysotile, nonferrous (short tons) :			
Crude No. 1 and No. 2	176	717	1,500
Crude No 3	150	333	...
Columbium-tantalum ores and concentrates (thousand pounds combined contained pentoxides)	3,486	7,354	15,000

Defence Minerals Exploration Administration.—On December 31, 1954, there were 217 contract projects. The Administration issues certifications of discovery or development. It is charged with the object of encouraging mineral research and exploration of strategic minerals from domestic sources. The Administration, in co-operation with the Geological Survey and the Bureau of Mines, pursues a programme to explore for strategic minerals and metals by offering Government financial assistance, on a participating basis, to the extent of 50% or 75% of the cost to the exploration projects of the mining industry or individuals. The Government's contribution is to be repaid on a percentage royalty basis from the net sales receipt for any ore produced. The financial assistance from DMEA and the Government's buying programme for various strategic Minerals stimulate exploration in the country and provide new resources of minerals.

National Strategic Stockpile programme.—Set up in 1953, the President's Cabinet Committee on Mineral Policy makes recommendations for national policies affecting the production and utilization of metals and minerals. A new long-term stockpiling programme with regard to strategic minerals and metals was formulated and approved by the President in March, 1954. The "Strategic and Critical Materials Stock-Piling Act" was passed by the Congress in 1946. There are three levels of stockpile objectives, namely, the minimum objective, the long-term objective, and the supplemental objective. In 1954, the value of strategic materials added to the strategic stockpile amounted to about $ 800 million, the total value of the National Stockpile on December 31, 1954, being about $ 5 billion. The General Services Administration buys all critical minerals for stockpiling.

Atomic Energy Commission.—Originally set up by legislation in 1946, the AEC Act of 1954 became law on August 30, and provides for greater research on peacetime applications of atomic energy and greater international co-operation. In the U. S. A., large output of uranium ores and concentrates occurred in recent years, increasing the number of potential sources. The purchasing programme of the AEC has been extended up to 1962.

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Ostracoda of Jurassic & Tertiary deposits from Kutch & Rajasthan (Jaisalmer), India 1

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ON OSTRACODA OF JURASSIC AND TERTIARY DEPOSITS FROM KUTCH AND RAJASTHAN (JAISALMER), INDIA*

(Figs. 1—2; Plates I—IV)

By

P. S. Lubimova, D. K. Guha and Madan Mohan.

ABSTRACT

The present work is devoted to the study of Ostracodes from the Jurassic, Eocene and Miocene deposits of Kutch and Jaisalmer regions of Western India. It establishes characteristic assemblages of Ostracodes for the above mentioned horizons and gives descriptions of Ostracodes met with. 35 species are described belonging to 16 genera and 4 families. All the species are new ones.

INTRODUCTION

This work deals with the study of Jurassic and Tertiary Ostracodes of Kutch and Jaisalmer regions of Western India. In these regions Jurassic and Tertiary deposits have wide distribution and area mainly represented by terrigenous rocks of considerable thickness. In these deposits, in several horizons were found rather variable species of ostracodes. Some of them are characterised by rapid changes in time due to which they are very valuable for stratigraphic subdivision.

The utilisation of ostracodes for determination of age and correlation of deposits has at present attained a wide scale, especially for the study of fresh-water continental deposits, in which ostracodes are almost the only micro-organisms. Besides that, due to their small size, ostracodes are very valuable for studying drill cores, in which fauna of large size is met with comparatively rarely. Representatives of different groups of ostracodes can live in different ecological conditions. Some of them live in marine and brackish waters, others in fresh water. This enables one, on the basis of ostracodes, to reconstruct those paleogeographical conditions in which various sediments were deposited and hence to give the correct direction to geological prospecting work.

Of late years ostracodes have become the subject of great attention on the part of geologists and palaeontologists, which is due to their abundance in marine and fresh water deposits of Paleozoic, Mesozoic and Kainozoic of various countries. Numerous works on Silurian, Devonian and Carbonian Ostracodes of the USSR and North America, Mesozoic and Tertiary ostracodes of the USSR, Western Europe, North America, Australia and other countries testify to the fact that of late ostracodes have assumed great importance in geological prospecting works.

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* Read before the Society on 29.2.60.

At present ostracodes have been found in a number of sections of Jurassic and Tertiary deposits of Kutch and Jaisalmer. It is quite possible that ostracodes may also be found in Tertiary continental deposits of the Sub-Himalayan depression, where, in the series of Lower and Middle Siwaliks there are clay bands favourable for their finding. The latter supposition is supported by the fact that in the USSR, in the continental Kainozoic deposits of Tian-Shan depression, where conditions of sedimentation were close to those in the Sub-Himalayan depression, fresh water Miocene and Pliocene ostracodes were found (Schneider, 1953). All this necessitates a detailed study of ostracodes in India, which undoubtedly will be of great importance for detailed stratigraphic subdivision of sedimentary deposits and specification of conditions of their deposition.

This work is the first one dealing with Jurassic and Tertiary ostracodes of Western India. It aims at establishing complexes of ostracodes for Jurassic and Tertiary deposits, determination and description of these complexes in order that in future, while carrying out more detailed study, they could be used for subdivision and correlation of sections of different regions.

Taking into account the fact that ostracodes of India have not been studied systematically, first of all it was necessary to describe these species, which are all new. At the first stage of investigation the authors studied ostracodes from the horizons already determined on the basis of other groups of fauna (Brachiopoda, Gastropoda, Pelecypoda, Ammonites, Foraminifera etc.). For the present investigations samples were taken from Jurassic and Tertiary deposits of Kutch, collected by M. C. Poddar and Kutch party and from Jurassic deposits of Jaisalmer, collected by Jaisalmer party. Collections of Mesozoic and Tertiary deposits from various regions of the USSR were used for comparison.

The system of collecting samples in these two regions was different. Kutch materials are represented by random samples containing abundant microfauna and taken from already known horizons. Jaisalmer samples were collected systematically and they contain very few ostracodes in poor preservation.

In the studied sections, ostracodes are most frequently found in Miocene deposits, where they are usually represented by numerous specimens of each species. They are considerably less numerous in Jurassic, Eocene and (?) Oligocene deposits.

This work gives description of 35 species of ostracodes from Jurassic and Tertiary deposits belonging to 4 families and 16 genera. All these species are established for the first time.

The study of ostracodes was carried out in the Palaeontology Laboratory of Oil and Natural Gas Commission by P. S. Lubimova (Soviet Expert) together with D. K. Guha and Madan Mohan. Few of the drawings were made at Leningrad Oil Research Institute and rest were drawn by Madan Mohan.

GEOLOGY OF KUTCH

(Fig. 1)

Previous work

Wynne[1] (1872) published the first detailed account of the geology of Kutch peninsula. Biostratigraphic investigation was carried out later by Waagen[2], Gregory[3], Kitchin[4], Spath[5], Cox[6] and Raj Nath[7]. Arkel[8] has also given a short account of geology of Kutch. The latest work on the stratigraphy of Kutch is that of Poddar[9]. The stratigraphic sequence in this area (after Poddar, 1959) is presented in table I.

Stratigraphic Sequence in the vicinity of the Peninsula of Kutch

Age.	Formation.	Thickness	Type of sediments.
Pleistocene & Recent	Alluvium, Rann and blown sand, Miliolite Limestone	10 m. ±	—
Pliocene	Manchhar Series	250 m. ±	Partially marine
	Unconformity		

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[1] Wynne, A.B. (1872) — Geology of Kutch, Mem. Geol. Surv. Ind., Vol. IX, pt. 1.

[2] Waagen, W. (1873-76) — Jurassic Fauna of Kutch, The Cephalopoda, Palaeontologia Indica, Ser. IX, Vol. I.

[3] Gregory, J.W. (1893) — The Echinoidea of Cutch, Pal. Ind., Ser. IX, Vol. II, pt. I.

3a. ... . (1900) — The Corals, Pal. Ind, Ser. IX, Vol. II, pt. 2.

[4] Kitchin, F.L. (1900) — The Brachiopoda, Pal. Ind., Ser. IX, Vol. III pt. I.

4a. .... (1903) — Lamellibranchiata: Genus *Trigonia*, Pal. Ind., Ser. IX, Vol. III, pt. 2.

[5] Spath, L.F. (1942) — On the Blake collection of Ammonites from Kachh, Pal. Ind., N.S, Vol. IX, Mem. I.

5a. .... (1927-1933) — Revision of the Jurassic Cephalopod Fauna of Kachh (Cutch),, Pal. Ind., N.S. Vol. IX, Mem. 2, pt. I (1927); pt. II (1928); pt. III (1928); pt. IV (1931); pt. V (1931); pt. VI (1933).

[6] Cox, L.R. (1940) — The Jurassic Lamellibranch Fauna of Kachh (Cutch), Pal. Ind, Ser. IX, Vol. III, pt. 3.

6a. .... (1952) — The Jurassic Lamellibranch Fauna of Cutch (Kachh), Pal. Ind., Ser. IX, Vol. III, pt. 4.

[7] Raj Nath (1942) — The Jurassic Rocks of Kutch (Presidential address—29th Indian Science Congress).

[8] Arkel, W.J. (1956) — Jurassic Geology of the world, pp. 382-392.

[9] Poddar, M.C. (1959) — Stratigraphy and Oil Possibilities in Kutch, Western India, Proceedings of the Symposium on the Development of Petroleum Resources of Asia and the Far East. Mineral Resources Development series, No. 10, pp. 146-148.

Age.	Formation.	Thickness.	Type of sediments.
Miocene	Argillaceous beds	300 m. ±	Marine
	Arenaceous beds	50 m. ±	Estuarine
		Unconformity	
? Oligocene	—	10 m. ±	Marine
Eocene	Nummulitic limestone Gypseous shale, etc.	200 m. ±	Marine
	Lateritic clays and laterite	30 m. ±	Terrestrial
Cretaceo-Eocene	Deccan trap	600 m. ±	Volcanic lavas
Mid. Cretaceous (? Albian)	Bhuj Series	300 m. ±	Fluviatile Estuarine
Neocomian-Aptian	Umia Series including Ukra beds	430 m. ±	Estuarine, partially marine
Kimmeridgian-Tithonian	Katrol Series	330 m. ±	Mostly marine
		Unconformity	
Callovian-Oxfordian	Chari Series with Dhosa oolite bands at top	430 m. ±	Marine
Bathonian older	Patcham Series	325 m. ±	Mostly marine
		Transgression	
	Crystalline basement		

Geology

Nonmarine and marine formations of Mesozoic, Tertiary and Quaternary age constitute the sediments of Kutch.

Jurassic rocks occupy a large area and are the oldest rocks except for some patches of Pre-Cambrian rocks. The Jurassic rocks have been divided into four well defined divisions named Patcham, Chari, Katrol and Umia series from below upwards.

The Patcham series, of Middle Jurassic age consists of hard oolitic, pisolitic and fossiliferous limestones with sandstones and shales and is overlain by the Chari series of late Jurassic age consisting mainly of fossiliferous shales and limestones. The Katrol series unconformably overlies the Dhosa oolites, the topmost bed of the Chari series. The Katrol series is composed of different types of sandstones and fossiliferous shales with grits in the upper part. The Katrol series is overlain by the Umia series, consisting of variegated sand-

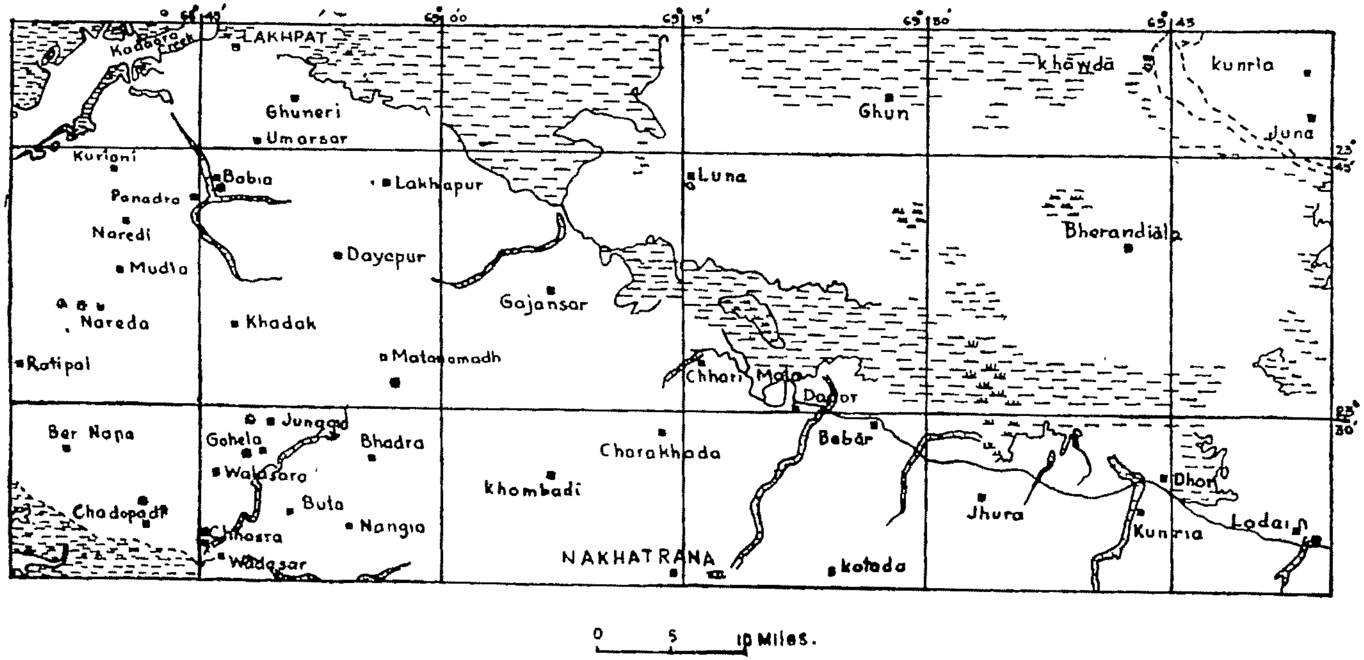

Fig. 1.

Sketch map of a part of Kutch showing the sample localities.

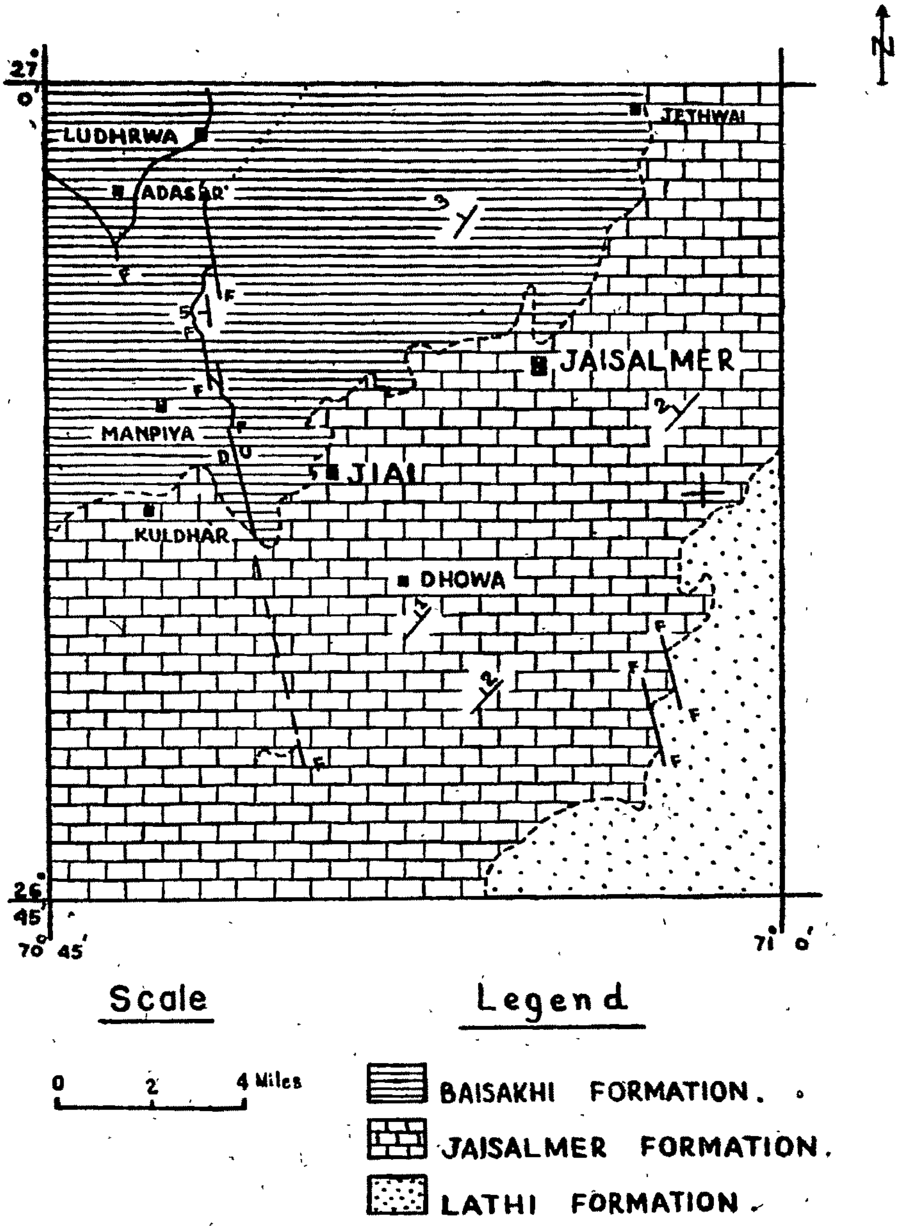

Fig. 2.

A part of Jaisalmer area.

stones with minor shales and clays. In the upper part of the Umia series, plant remains probably of early Cretaceous age are associated with the coal bands. In Umia series, a few marine bands are found in western part of the peninsula. The uppermost portion of the Umia series contains an ammonite bed probably of Aptian age.

The Bhuj series overlying the Umia series consists of soft, massive, current bedded sandstones with minor sandy shales which at some places contain very poorly preserved plant remains.

The Deccan trap lava flows of late Cretaceous to Paleocene age overlies the Mesozoic sediments. The upper part of the traps are lateritised and are overlain by gypseous shales, pyritous lignites, resin bands and nummulitic limestones of Eocene age.

The Eocene beds are unconformably overlain by Miocene shales and sandstones which are associated with marls and dark clays with abundant marine fossils.

The Miocene beds are overlain by Manchhar series consisting of marls, grits and unconsolidated sands of Pliocene age. Unconsolidated sands, dark clays and occasional saline encrustations of Pleistocene to Recent age overlies the Manchhar series. They are developed mostly in the coastal areas and in the Rann of Kutch.

The Mesozoic and Tertiary formations have been subjected to folding movements of late Tertiary to Quaternary age and are folded into three or more parallel series of anticlines and domes trending almost east west. The anticlines are generally asymmetric in character, the northern flank being steeper than the southern flank. The compressive stresses probably began in Miocene time and continued intermittently right upto Pleistocene and even to Recent times.

GEOLOGY OF JAISALMER

(Fig 2)

Previous work

The first geological investigation in this area was carried out by Blanford[1] (1877), and the mapping of the area was done by Oldham[2] (1886). It was followed by La Touche[3] (1902) who checked and compiled a map of entire sedimentary basin of Jodhpur—Bikaner—Jaisalmer states. Subsequent work in this area has been carried out by Ghosh[4] (1952), Allison[5] (Arkel, 1956), Singh[6] (1953) and Swaminath[7], J. and others (1959).

Geology

Beds of this area generally dip 1-2° towards NW or WNW. Sometimes the beds are nearly horizontal. The maximum thickness of the sediments, which is of the order of 1830 metres near Jaisalmer increases gradually towards NW, where it is of the order of 7925 metres, thus clearly indicating a general deepening of the basin towards NW.

The structure of the area is a large gentle monocline with two flexures and several minor folds and normal step faults.

The chronological succession of the beds as established by Geological Survery of India in 1955-56 field season is as follows :

Age.	Formation.	Maximum Thickness
Sub-Recent	Quartz pebbles with some Jasper and flint	(?)
Lower Eocene	Nummulitic limestones	46 metres
——	Unconformity with overlap	
Cretaceous	Abur formation: Shell limestones, grits, calcareous sandstones and quartzites	108 metres
——	Unconformity with overlap	

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[1] Blanford, W. T. (1877), Geological notes on the Great Indian Desert between Sind and Rajputana, Rec Geol. Surv. India, Vol. X, pt. 1.

[2] Oldham, R. D. (1886), Preliminary Note on the Geology of Northern Jaisalmer, Rec. Geol. Surv. India, Vol XIX, pt. 3.

[3] La Touche, T. D. (1902), Geology of Western Rajputana, Mem. Geol. Surv. India, Vol. 35, pt. 1.

[4] Ghosh, P. K. (1952), Western Rajputana—its tectonics and minerals including Evaporites. Proc. Sym. on the Rajputana Desert Bull. No. I, Nat Inst. Sc. India

[5] Allison, A. (1939), Unpublished report to the Burma Oil Company in Arkell, W. J. (1956), Jurassic Geology of the World.

[6] Singh, S. N. (1953), Geology of area WSW of Marh village near Kolayat, Bikaner, Rajasthan. Proc. Nat. Acad. Sc. India, Vol. 23, pt. I-III.

[7] Swaminath, J. & others (1959), General Geology of the Jaisalmer area, Rajasthan, India. Proceedings of the Symposium on the development of Petroleum Resources of Asia and the Far East. Mineral Resources Development Series, No: 10.

Age.	Formation.	Maximum Thickness
Jurassic	Parihar formation: Soft, fragile, ferruginous felspathic sandstones, unfossiliferous	843 m. (?)
	Badasar formation: hard, compact, ferruginous grits, concretionary calcareous sandstones and sandy shales.	365 metres
	—Unconformity—	
	Baisakhi formation: hard, compact sandstones, concretionary sandy limestones and sandy shales with conglomerates at base.	596 m. (?)
	—Disconformity—	
	Jaisalmer formation: hard, compact limestones and compact sandy limestones.	355 meters
	Lathi formation : highly current—bedded, fragile coarse grained sandstones, ferruginous sandstones with dicotyledonous wood.	90 metres

The Lathi formation contains fragments of fossil wood, one of which has been determined to be a gymnosperm. This formation grades into Jaisalmer formation without any break in sedimentation.

In the Jaisalmer formation seven marker horizons were determined on the basis of faunal content. Marker VII, composed of shales and limestones with golden oolites is considered to be the transitional zone between Jaisalmer and Baisakhi formations. Samples from Jaisalmer formation were studied by the authors.

The Baisakhi formation was divided into 3 lithological units A, B and C as there is no biological control in it like the Jaisalmer formation.

The Badasar formation unconformably overlying the Baisakhi formation may be correlated with the Katrol series of Kutch.

The Parihar formation assumed to lie conformably over the Badasar formation, can be correlated with Umia beds of Kutch.

The Abur formation contains some ammonites. Its contact with the Parihar formation is probably unconformable, although the field contact is apparently conformable.

The Eocene sediments composed mainly of siliceous limestones with rare Fuller's earth and clays are full of corals, echinoids, nummulites and other fossils.

Scattered patches of rounded pebbles of Sub-Recent age overlie all the formations.

STRATIGRAPHIC DISTRIBUTION OF OSTRACODES IN THE JURASSIC AND TERTIARY DEPOSITS OF KUTCH AND JAISALMER

I. Stratigraphic distribution of ostracodes in the Jurassic of Kutch and Jaisalmer (Table No. 1)

In the region of Kutch, the authors of this work dealt only with ostracodes from the *Chari* series, referred to the Callovian and Oxfordian, from SE of Lodai (23° 23′:69° 54′) and Khawda (23° 50′:69° 44′). Lithologically it is represented by shales and shaly limestones containing microfauna. These contain rather few ostracodes (Table No. 1) which are represented by the following species :

**Cytherella obscura* Lubimova and Mohan n.sp.
Cytherella disjuncta Lubimova and Mohan n.sp.
Cytherelloidea difficila Lubimova and Mohan n.sp.
Paracypris contermia Lubimova and Mohan n.sp.
**Progonocythere grumosa* Lubimova and Mohan n. sp.
**Progonocythere laeviscula* Lubimova and Mohan n.sp.
**Progonocythere implicata* Lubimova and Mohan n.sp.
**Progonocythere prolata* Lubimova and Mohan n.sp.

The species marked with * are more common and others are present in small number.

In the region of Jaisalmer the authors studied only the upper part of the *Jaisalmer formation* composed of grey sandy shales from west of Kuldhar (26° 52′:70° 47′). Here the following species were found.

Progonocythere aff. *obscura* Lubimova and Mohan n.sp.
Progonocythere implicata Lubimova and Mohan n.sp.
Progonocythere prolata Lubimova and Mohan n.sp.
Progonocythere sp. juv.
Progonocythere sp. indet.
Bythocythere sp. juv.

All these species are found from a small number of specimens.

These ostracodes are represented by new species and their stratigraphic distribution requires further detailed study.

II. Stratigraphic distribution of ostracodes in the Tertiary of Kutch. (Table No. 2)

The authors studied ostracodes only from the Eocene and Miocene (Gaj beds) deposits of Kutch. Samples of the Eocene beds were taken from Gypseous shale below *Assilina granulosa,* west of Nareda (23° 34′:68° 41′) and from the Nummulitic limestone near Babia hill (23° 42′:68° 49′) and they contain (Table-2) the following species of ostracodes :

Bairdoppilata poddari Lubimova and Mohan n.sp.
Paracypris meridionalis Lubimova and Mohan n.sp.
Krithe autochthona Lubimova and Guha n.sp.
Cythereis spinellosa Lubimova and Guha n.sp.
Cythereis arcanus Lubimova and Guha n. sp.
Trachyleberis tumefacentis Lubimova and Guha n.sp.
Trachyleberis memorans Lubimova and Guha n.sp.

These species have been met with in small quantity of the material studied.

In the Gaj beds (Argillaceous group) of Kutch, ostracodes are rather variable both in generic and specific composition and are most abundant in the vicinity of Chadopadi (23° 22′:68° 44′), Chaasra (23° 21′:68° 48′) and Matanumaud (23° 32′:69°).

Samples collected from brownish sticky clay underlying the *Archais* band, from NE of Chadopadi, yielded the following species of ostracodes :

Cytherella protuberantis Lubimova and Guha n.sp.
**Paracypris meridionalis* Lubimova and Mohan n.sp.
Krithe autochthona Lubimova and Guha n.sp.
Leptocythere chadopadiensis Lubimova and Guha n.sp.
Clythrocytheridea autonoma Lubimova and Guha n.sp.
**Cyprideis chaudhuryi* Lubimova and Guha n.sp.
Trachyleberis fossularis Lubimova and Guha n.sp.
**Trachyleberis tumefacentis* Lubimova and Guha n.sp.
**Trachyleberis chaasraensis* Lubimova and Guha n.sp.
Cytheretta trifurcata Lubimova and Guha n.sp.

The species marked with * are more common.

Samples collected in the north of Chadopadi from the clay band above the *Archais* band, are represented by the following species :—

**Cytherella protuberantis* Lubimova and Guha n.sp.
Cytherelloidea cutchensis Lubimova and Guha n.sp.
**Paracypris meridionalis* Lubimova and Mohan n.sp.
**Krithe autochthona* Lubimova and Guha n.sp.
Leptocythere chadopadiensis Lubimova and Guha n.sp.
**Clythrocytheridea autonoma* Lubimova and Guha n.sp.
**Cyprideis chaudhuryi* Lubimova and Guha n.sp.
Cythereis latebrosa Lubimova and Guha n.sp.
**Trachyleberis fossularis* Lubimova and Guha n.sp.
Trachyleberis mutata Lubimova and Guha n.sp.
**Trachyleberis tumefacentis* Lubimova and Guha n.sp.
**Trachyleberis chaasraensis* Lubimova and Guha n.sp.
Paijenborchella prona Lubimova and Guha n.sp.
Cytheretta secedens Lubimova and Guha n.sp.

**Cytheretta trifurcata* Lubimova and Guha n.sp.
Paracytheridea perspicua Lubimova and Guha n.sp.
Cytherura interposita Lubimova and Guha n.sp.
Cytheropteron confinis Lubimova and Guha n.sp.

Among them the species marked by * are most common in these deposits.

The above—cited complex of ostracodes is close to that from brownish sticky clay below the *Archais* band, NE of Chadopadi, but it is considerably more variable in specific composition and especially in the number of specimens.

In the Miocene complex from clay band above *Archais* band the following species are present, which are absent in sticky clay band below *Archais* band :

Cytherelloidea cutchensis Lubimova and Guha n.sp.
Cythereis latebrosa Lubimova and Guha n.sp.
Trachyleberis mutata Lubimova and Guha n.sp.
Paijenborchella prona Lubimova and Guha n.sp.
Cytheretta secedens Lubimova and Guha n.sp.
Paracytheridea perspicua Lubimova and Guha n.sp.
Cytherura interposita Lubimova and Guha n.sp.
Cytheropteron confinis Lubimova and Guha n.sp.

Samples collected from Gaj clay, 1 mile north of Chaasra, contain the following species of ostracodes :

**Cytherella protuberantis* Lubimova and Guha n.sp.
Cytherelloidea cutchensis Lubimova and Guha n.sp.
Cytherelloidea insolensa Lubimova and Guha n.sp.
Cytherelloidea costatruncata Lubimova and Mohan n.sp.
Bairdoppilata poddari Lubimova and Mohan n.sp.
Paracypris meridionalis Lubimova and Mohan n.sp.
**Krithe autochthona* Lubimova and Guha n.sp.
Leptocythere affinis Lubimova and Mohan n.sp.
Leptocythere chadopadiensis Lubimova and Guha n.sp.
Clythrocytheridea autonoma Lubimova and Guha n.sp.
**Cyprideis chaudhuryi* Lubimova and Guha n.sp.
Cythereis latebrosa Lubimova and Guha n.sp.
Cythereis pulcheris Lubimova and Guha n.sp.
**Trachyleberis fossularis* Lubimova and Guha n.sp.
**Trachyleberis mutata* Lubimova and Guha n.sp.
**Trachyleberis tumefacentis* Lubimova and Guha n sp.
**Trachyleberis chaasraensis* Lubimova and Guha n.sp.
**Paijenborchella prona* Lubimova and Guha n.sp.
Cytheretta secedens Lubimova and Guha n.sp.
**Cytheretta trifurcata* Lubimova and Guha n.sp.
Paracytheridea perspicùa Lubimova and Guha n.sp.

Cytherura interposita Lubimova and Guha n.sp.
Cytheropteron confinis Lubimova and Guha n.sp.
Species marked with * are most common.

All species of this complex excepting—
Bairdoppilata poddari Lubimova and Mohan n.sp.
Cytherelloidea insolensa Lubimova and Guha n.sp.
Leptocythere affinis Lubimova and Mohan n.sp.
are also met with in the deposits of brownish sticky clay below *Archais* band, NE of Chadopadi and in the clay band above *Archais* band, north of Chadopadi. It should be noted that some of them, e.g. *Bairdoppilata poddari* Lubimova and Mohan n.sp., *Paracypris meridionalis* Lubimova and Mohan n.sp., *Krithe autochthona* Lubimova and Guha n.sp., *Trachyleberis tumefacentis* Lubimova and Guha n.sp. are also found in the Eocene beds of Kutch. *Cytherelloidea insolensa* Lubimova and Guha n.sp., *Cytherelloidea costatruncata* Lubimova and Mohan n.sp., *Leptocythere affinis* Lubimova and Mohan n.sp. have been met with only in the Gaj beds of Kutch.

By comparing the Miocene complex of ostracodes with that of Eocene, one can notice that the former is more variable in specific and generic composition and considerably more numerous in the number of specimens. The Miocene complex contains a number of species which have not been found in the Eocene of Kutch. They are :

Cytherelloidea cutchensis Lubimova and Guha n.sp.
Cytherelloidea insolensa Lubimova and Guha n.sp.
Cytherelloidea costatruncata Lubimova and Mohan n.sp.
Leptocythere affinis Lubimova and Mohan n.sp.
Leptocythere chadopadiensis Lubimova and Guha n.sp.
Clythrocytheridea autonoma Lubimova and Guha n.sp.
Cyprideis chaudhuryi Lubimova and Guha n.sp.
Cythereis latebrosa Lubimova and Guha n.sp.
Cythereis pulcheris Lubimova and Guha n.sp.
Trachyleberis fossularis Lubimova and Guha n.sp.
Trachyleberis mutata Lubimova and Guha n.sp.
Trachyleberis chaasraensis Lubimova and Guha n.sp.
Paijenborchella prona Lubimova and Guha n.sp.
Cytheretta secedens Lubimova and Guha n.sp.
Cytheretta trifurcata Lubimova and Guha n.sp.
Paracytheridea perspicua Lubimova and Guha n.sp.
Cytherura interposita Lubimova and Guha n.sp.
Cytheropteron confinis Lubimova and Guha n.sp.

It is possible that the difference in these complexes is connected with different conditions of deposition. It should be also borne in mind that the Miocene deposits of Kutch were represented by a larger number of samples than Eocene.

The present work reveals 27 species of ostracodes, belonging to 15 genera and 4 families—Cytherellidae, Bairdiidae, Cypridae and Cytheridae from Eocene and Miocene deposits of Western India.

Irregularity of distribution of this group of organisms in separate beds and small quantity of systematically collected material, which is most important, do not allow at the moment to determine horizons on the basis of ostracodes. For carrying out this task it is necessary to undertake a detailed study of ostracodes on the samples collected systematically across the section. At the first stage of study of ostracodes, it was possible only to determine their complexes which are represented by new species, whose stratigraphic distribution requires further detailed study.

CHARACTERISTICS OF JURASSIC AND TERTIARY OSTRACODES OF KUTCH AND JAISALMER

From the above mentioned facts it may be concluded that ostracodes from the Jurassic, and Tertiary deposits of Kutch and Jaisalmer are represented by different complexes. The samples from Jurassic deposits which by its age is referred to the Callovian and Oxfordian, is rather poor both in quantity and specific composition of ostracodes. They belong to 12 species and 5 genera, combined in 4 families: Cytherellidae (genera: *Cytherella, Cytherelloidea*), Cypridae (genus: *Paracypris*), Cytheridae (genus:*Progonocythere*) and Paradoxostomidae (genus: *Bythocythere*).

Representatives of the above genera are widely distributed in the Jurassic, and in particular, in the equivalent deposits of the USSR—Eastern Ukraine and the Volga-Ural regions and are also found in the deposits of the same age in England (Sylvester-Bradley, 1948), France, Poland (Terquem, 1886) and Germany (Triebel, 1938). As a rule they have massive and sculptured shell characteristic of representatives of coastal zones or shallow marine basins.

Ostracodes from Eocene and Miocene deposits, are represented by 27 species, which are new ones. This fauna belongs to 4 families and 15 genera and differs considerably from the Jurassic fauna both in specific and generic composition.

Ostracodes from the Eocene and Miocene deposits are rather close in generic composition. However, they differ in specific complexes, which makes it possible to distinguish them from each other.

Ostracodes were met in deposits of different facies. Their generic and specific composition is different in different rocks. Most abundant complexes were observed in clay sediments, in the brownish sticky clay below the Archais band, in the clay band above the Archais band (Chadopadi) and in Gaj clay (Chaasra). In considerably less quantity they were met with in the Gypseous shale bed below *Assilina granulosa* and in Nummulitic limestone. In sandy rocks as a rule they are not found. According to O. Elofson (Elofson, 1941) this may be explained by the fact that for ostracodes a clayey bottom containing 18-45% of ooze is the most favourable place for habitation. Bottoms containing less quantity of ooze are poor in food, whereas those with its larger contents are difficult for locomotion.

The ostracodes studied have, as a rule, massive, in most cases, sculptured shells, characteristic of representatives of shallow marine basin or coastal zone. On the basis of comparison with recent ostracodes it may be supposed that ostracodes with such a shell were of benthonic type, that they lived at the oozy bottom and locomoted by crawling. Various protuberances (spines, tubercles etc.), probably, helped them to remain on the surface of substratum and not to sink down into ooze.

The studied species belong to the families Cytherellidae, Cypridae, Bairdiidae and Cytheridae.

Specimens of family Cypridae are rather few in number and are represented only by the genus *Paracypris.* Fossil species of this genus are met with starting from Jurassic. Their recent representatives live in marine waters with normal salinity. Family Cytherellidae is represented only by two genera: *Cytherella* and *Cytherelloidea.* Various species of these genera are met with from Jurassic to Recent. These are exclusively marine organisms with smooth (genus *Cytherella*) or sculptured (genus *Cytherelloidea*) shells. By their shape of the valves and hinge, they resemble Paleozoic genus *Cavellina,* but differs from it in having different structure of tubercles of adductor and mandibular muscles. In the Tertiary deposits an exclusively wide development has been assumed by the family Cytheridae, represented by 11 genera: *Krithe, Leptocythere, Clythrocytheridea, Cyprideis, Cythereis, Trachyleberis, Paijenborchella, Cytheretta, Paracytheridea, Cytherura* and *Cytheropteron.* In the studied deposits the above mentioned genera are met distributed irregularly. So, genus *Krithe* is represented only by one species (*Krithe autochthona* Lubimova and Guha n.sp.). This species is found in the Kirthar and Gaj beds, the latter being represented by a large number of specimens. Species of genus *Cythereis* are relatively more abundant. Four species of this genus have been met with, two of them (*Cythereis spinellosa* Lubimova and Guha n.sp. and *Cythereis arcanus* Lubimova and Guha n.sp.) were found in the Kirthar beds, and two species (*Cythereis latebrosa* Lubimova and Guha n.sp. and *Cythereis pulcheris* Lubimova and Guha n.sp.) only in the Gaj beds, represented by few shells.

Representatives of genera *Leptocythere, Clythrocytheridea, Paijenborchella, Paracytheridea, Cytherura* and *Cytheropteron* have been met with only in the Gaj beds where they are rather few. In the Tertiary deposits wide development was assumed by species of genera *Cyprideis, Cytheretta* and *Trachyleberis.* The first two genera were found only from the Gaj beds and the last one is found both in the Gaj and Eocene beds, being relatively more common in the former.

It is interesting to note that the Tertiary deposits of Kutch contain representatives of family Bairdiidae, e.g. genus *Bairdoppilata,* found both in the Kirthar and Gaj beds, though they are not numerous.

The above cited fauna is characteristic of deposits of marine basins, mostly with normal salinity. The only exception is genus *Cyprideis* whose species are widely developed both in marine and brackish basins.

By the generic composition ostracodes of the Tertiary deposits of Kutch are similar to ostracodes of the same age, found in the USSR (Crimea, Caucasus, Ukraine), Western Europe, North America, New Zealand and other countries. However, due to the fact that the species under investigation are new, it is not possible at present to carry out comparison of these complexes by their specific composition.

DESCRIPTION OF OSTRACODA

Class *Crustacea* Brongniart and Desmares, 1822

Subclass *Ostracoda* Latreille, 1806

Order *Podocopida* Muller, 1894

Family *Cytherelloidae* Sars, 1865

Genus *Cytherella* Jones, 1849

*Cytherella obscura** Lubimova and Mohan n.sp. (Pl. I, figs. 1a, b)

Holotype :—No. I- 1 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, Khawda; Callovian.

Original :—No. I-11 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, Khawda; Callovian.

Description :—Shell elongate, irregularly oval, with maximum thickness in the posterior part, gradually reducing towards margins. Left valve slightly larger than right, overlapping it all around. Anterior end high, symmetrically rounded. Posterior end nearly of the same height as anterior, with the upper part more sharply rounded than lower. Dorsal margin convex, gradually merging with the ends. Ventral margin slightly convex, also gradually merging with the ends. Surface of the valves smooth.

Size in mm

Dimensions	Holotype No. I-1	Original No. I-11
Length	0.59	0.50
Height of anterior end	0.28	0.26
Height of posterior end	0.26	0.23
Thickness	0.22	0.20

Comparison :—In general outline of the shell the species in question is very close to *Cytherella glanduliformis* (Terquem) described by Terquem (Terquem, 1886, p. 25, Pl. XVII, figs. 9 a, b) from Middle Jurassic deposits (Fuller's Earth) in the vicinity of Warsaw. *Cytherella glanduliformis* (Terquem) differs from the described species in having more convexed dorsal and ventral margins and different size. The species in question is also close to

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* Indistinct

Cytherella ovula (Terquem) described by Terquem from the same deposits of Warsaw (Terquem, 1886, p. 92, Pl. XVII, figs. 1 a, b), but it differs from the latter in having more convex dorsal and ventral margins.

Geographical distribution and geological age :—Khawda, Kutch; 3 miles north east of Amarsagar, Jaisalmer, Callovian.

Material :—In the author's collection there are few shells in fair preservation.

*Cytherella disjuncta** Lubimova and Mohan n.sp. (Pl. I, figs. 2 a, b, c)

Holotype :—No I- 2 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, Khawda; Callovian.

Description :—Shell elongate, oval, with maximum thickness in the posterior part. Left valve larger than right, overlapping it all around, more prominently at dorsal and ventral margins. Anterior end high, broad and symmetrically rounded. Pasterior end of same height as anterior, in the upper part gently sloping and in the lower part more sharply rounded. Dorsal margin canvex gradually connected with the ends. Ventral margin convex with a slight median depression and gradually connected with the ends. Surface of the valves smooth.

Size in mm.

Dimensions	Holotype No. I- 1
Length	0.62
Height	0.36
Thickness	0.28

Comparison :—By the shape of the shell and outline of the ends, *Cytherella disjuncta* Lubimova and Mohan n.sp. resembles *Cytherella oliviformis* (Terquem), described by Terquem (Terquem, 1885, p. 18, Pl. III, figs. 2 a, b) from Middle Jurassic deposits (Oolitic system, zone Ammonites parkinsoni) of France (Moselle). The species in description differs from it in having more convex dorsal margin and distinct asymmetry of the valves. The species in question is also close to *Cytherella glanduliformis* (Terquem) and *Cytherella ovula* (Terquem) described by Terquem (Terquem, 1886, p. 95, Pl. XVII, fig. 9 a and p. 92, Pl. XVII, figs. 1 a, b) from Middle Jurassic deposits (Fuller's Earth) in the vicinity of Warsaw, but it differs in having more convex dorsal margin and very asymmetrical valves.

Geographical distribution and geological age :—Khawda, Kutch, Callovian.

Material :—In the author's collection there are few shells, in fair preservation.

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* distinct

*Cytherella protuberantis** Lubimova and Guha n. sp.
(Pl. I, fig. 3)

Holotype :—No. II- 1 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, Chassra, Miocene.

Original :—No. II- 35 in the collection of Paleontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, Chaasra, Miocene.

Description :—Shell large, rectangular rounded, with maximum thickness and height in the posterior part. Left valve is larger than the right and overlaps it all around. Overlapping prominent at dorsal and ventral margins, at anterior and posterior ends it is inconspicuous. Anterior end high and regularly rounded. Posterior end slightly higher than anterior, rounded in the upper part and in the lower part it is sloping towards ventral margin. Dorsal margin straight, gradually connected with the ends. Ventral margin concave in the middle part and gradually connected with the ends. Surface of the valves smooth.

Size in mm.

Dimensions		Holotype No. II-1	Original No. II-35	Other Specimens No. 1	No. 2
Length ..	..	0.68	0.73	0.64	0.69
Height of anterior end	..	0.36	0.39	0.36	0.38
Height of posterior end	..	0.42	0.42	0.38	0.42
Thickness of shell	..	0.33	0.35	—	0.35
Thickness of valve	..	—	—	0.17	—

Variation :—This is expressed in different degree of overlapping and difference in the size of the shell.

Comparison :—*Cytherella protuberantis* Lubimova and Guha n. sp. is very close to *Cytherella beyreichia* (Reuss) described by Schmidt (Schmidt, 1948, p. 406, Pl. 61, fig. 2) from Tertiary of North America, but differs from the latter in being more elongated, in having straight dorsal and concave ventral margins, and in not having the central socket. *Cytherella protuberantis* Lubimova and Guha n.sp. in shape and outline also resmbles *Cytherella compressa* Munster, described by Bosquet (Bosquet, 1852, Pl. 1, fig. 1) from Tertiary of France and *Cytherella retrorsa* Mandelstam, described by M.I. Mandelstam (Mandelstam, 1955, Pl. III, fig. 45) from Paleogene of Middle Asia, but differs from the first in having straight dorsal margin and from the second in having more gentler slope in the lower part of the posterior end.

Distribution and geological age :—Kutch, in the locality of Chaasra, Chadopadi, Matanumaud and Gohela; (?) Oligocene and Miocene.

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* Projected.

Material :—Collection contains about fifty shells and valves in different degree of preservation.

Genus *Cytherelloidea* Alexander, 1939

*Cytherelloidea difficila** Lubimova and Mohan n. sp.
(Pl. I, figs. 4a, b)

Holotype :—No. I- 3 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, Khawda; Callovian.

Description.—Shell thin, flat, elongate, rounded rectangular. Overlapping indistinct. Anterior and posterior ends equally high, broad and symmetrically rounded. Dorsal margin straight, gradually merging with ends. Ventral margin with depression in the middle part, also gradually merging with ends. On the surface of the valves there is one costa, with low and rounded faces, running parallel to margins and ends. Rest of the surface smooth.

Size in mm

Dimensions	Holotype No. 1-3
Length	0.63
Height	0.35
Thickness	0.08

Comparison :—By the outline of the shell the species in description is very close to *Cytherelloidea oolithica* Terquem var. described by Terquem (Terquem, 1885, p. 43, Pl. VI, fig. 15) from the Middle Jurassic deposits of France (Moselle, zone Ammonites parkinsoni), but it differs from it in having less distinct costate sculpture and not having middle arch-shaped costa. From species *Cytherelloidea ornata* Lubimova, described by P. S. Lubimova (Lubimova, 1955, p. 111, Pl. XIII, fig. 4 b) from Upper Jurassic deposits (Lower Volga stage), Volga region, USSR, this species differs in having circular costa near the centre of the valve, whereas in the described species it runs near the margins.

Geographical distribution and geological age :—Kutch, Khawda; Callovian.

Material :—In the author's collection there are few shells, fairly well preserved.

*Cytherelloidea cutchensis***, Lubimova and Guha n. sp.
(Pl. I, figs. 5a, b)

Holotype :—No. II- 2 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra, Miocene.

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* Difficult.

** Name given after the region where it was first found.

Original :—No. II- 36 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra, Miocene.

Description.—Shell large, irregularly oval, with maximum thickness in the posterior part and maximum height in the anterior part of the valve. Left valve larger than right and overlaps it all around. Overlapping is more prominent in dorsal and ventral margins. Anterior end high, symmetrical and regularly rounded. Posterior end is of same height, regularly rounded in the upper part, the lower part gradually sloping towards ventral margin. Dorsal margin more or less straight. Ventral margin concave in the middle. Both dorsal and ventral margins merge with the ends gradually. Sculpture is represented by a low rib running from the central part of the valve to the posterior end where it makes a sharp turn running parallel to the posterior end and ends at the postero-ventral corner. Rest of the surface smooth.

Size in mm.

Dimensions	Holotype No. II-2	Original II-36	Other Specimens No. 1	No. 2	No. 3
Length	0.57	0.57	0.57	0.59	0.57
Maximum height	0.36	0.35	0.35	0.36	0.36
Thickness of shell	0.26	0.25	x	0.26	0.25
Thickness of valve	x	x	0.15	x	x

Variation.—This is expressed in different degree of overlapping and development of rib.

Comparison.—*Cytherelloidea cutchensis* Lubimova and Guha n. sp. has rather original sculpture and can not be compared with other species known in literature.

Geographical distribution and geological age.—Kutch, locality Chaasra and Chadopadi; Miocene.

Material.—Collection contains 15-20 shells and valves in different degree of preservation.

*Cytherelloidea insolensa** Lubimova and Guha n.sp.

(Pl. I, figs. 6a, b)

Holotype.—No. II- 3 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Original.—No. II- 37 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Description.—Shell irregularly oval, maximum thickness in posterior part and maximum height in anterior. Left valve is larger than right. Overlapping is distinct only at the dorsal margin. Anterior end high, symmetrical and regularly rounded. Posterior end lower than anterior, evenly rounded in the upper part, lower part sloping gently towards the ventral margin. Dorsal margin straight, gradually connected with the anterior end, with the posterior end forms a rounded obtuse angle. Ventral margin with slight depression in its middle part, gradually connected with anterior end and with the posterior end forms a rounded obtuse angle. In the posterior part there is a small crescent-shaped rib facing towards the anterior end. Besides, a thin, low and rounded costa runs along, and parallel to the margin and ends, which becomes indistinct in the posterior part. Rest of the surface smooth.

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* Extraordinary

Size in mm.

Dimensions	Holotype No. II-3	Original No. II-37	Other Specimen No. 1
Length	0.55	0.54	0.62
Maximum height ..	0.33	0.32	0.32
Thickness of shell ..	0.15	0.14	0.21

Comparison.—*Cytherelloidea insolensa* Lubimova and Guha n.sp. has rather original sculpture. It has not got any resemblance with other species known to the authors.

Geographical distribution and geological age.—Kutch, locality Chaasra; Miocene.

Material.—Collection contains few shells in different degree of preservation.

*Cytherelloidea costatruncata** Lubimova and Mohan n. sp.

(Pl. I, fig. 7)

Holotype.—No. II- 4 in the collection of Palaeontology laboratory, Oil & Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra, Miocene.

Original.—No. II- 38 in the collection of Palaeontology laboratory, Oil and Natural Gas Comission, Dehra Dun; Kutch, 1 mile north of Chaasra, Miocene.

Description.—Shell, oval elongated, close to ellipsoidal, with maximum thickness in the posterior part and gradually reducing towards the anterior end, becoming flat. Left valve is bigger than right and overlaps the latter all around. Overlapping is most prominent on the dorsal and ventral sides. Anterior end is high, evenly and symmetrically rounded. Posterior end is of same height and rounded in the same way. Dorsal margin straight, more evenly connected with the posterior end. Ventral margin slightly concave in the anterior part. On the surface of valve there is a low circular costa with smoothed edges, running along the margins and ends. In the posterior part of the valve the costa gets considerably thicker and forms almost right angle in postero-ventral and postero-dorsal parts. Surface of valves between the ribs has indistinct, rounded, tetrahedral or pentahedral reticules with thick and low faces.

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* Truncated costae.

Size in mm.

Dimensions	Holotype No. II- 4	Original No. II- 38
Length	0.65	0.63
Height	0.38	0.36
Thickness of posterior end	0.28	0.28
Thickness of anterior end	0.14	0.17

Comparison.—The species in question has some resemblance with *Cytherelloidea californica* Le Roy, described by Le Roy (Le Roy, 1943, p. 357, Pl. 58, figs. 32-35) from Pleistocene of California, but differs from it in having a straight dorsal margin and less developed costate sculpture. The described species has only one circular costa whereas *Cytherelloidea californica* Le Roy has a supplementary costa in the middle part of the valve surface. From *Cytherelloidea umbonata* Edwards, described by Edwards (Edwards, 1944, p. 506, Pl. 85, figs. 1, 2) from Miocene deposits of North Carolina, this species differs in shape of the shell, different disposition of costa on the surface of valves and by the absence of well expressed reticulate sculpture. From other species of *Cytherelloidea,* described by Le Roy from Middle and Upper Tertiary of Netherlands, *Cytherelloidea costatruncata* Lubimova and Mohan n.sp. differs by absence of median costae on the surface of valves.

By the shape of the shell and the presence of circular costa this species resembles *Cytherelloidea vallaris* (Mandelstam) described by M. I. Mandelstam from Palaeogene of Middle Asia (Mandelstam, 1955, Tab. III, figs. 38, 39) differs from the latter by different (angular) disposition of the costa in the posterior part of valve and reticules on the surface of valves.

Geographical distribution and geological age.—Kutch, 1 mile north of Chaasra, Miocene.

Material.—Collection contains few shells in fair preservation.

Family *Bairdiidae* Sars, 1887.

Genus *Bairdoppilata* Coriel, Sample and Jenings, 1935.

*Bairdoppilata poddari** Lubimova and Mohan n.sp.
(Pl. II, figs. 1a, b)

Holotype.—No. II- 5 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 2½ miles west of Nareda; Eocene.

Original.—No. II- 39 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 2½ miles west of Nareda; Eocene.

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* Name is given after Mr. M. C. Poddar.

Description.—Shell with thick wall, deltoid, maximum height and maximum thickness in the middle part, gradually reducing towards the ends and margins with distinct asymmetrical valves. Left valve considerably larger than right and overlaps the latter all around. Overlapping is most prominent along the dorsal margin and the middle part of ventral margin. At the ends it is inconspicuous. Anterior end high, with distinct slope in the upper part, in the lower part gently rounded and slightly elevated. Posterior end with intense slope in the upper and middle parts, gently rounded in the lower part and slightly elevated. Dorsal margin arch-shaped, gradually and symmetrically connected with the ends. Ventral margin concave in the middle part, evenly connected with the ends. Surface of the valves smooth.

Size in mm.

Dimensions	Holotype No. II-5	Original No. II-39
Length	1.17	1.05
Maximum height	0.78	0.68
Thickness	0.70	0.70

Comparison.—By general outline of the shell this species resembles *Bairdia magna* Alexander, described by Alexander (Alexander, 1927-28, p. 32, Pl. 6, fig. 7) from Upper Cretaceous of Texas, but differs from it in having larger size, different dorsal margin, more distinct slope in the upper part of the anterior end and less distinct slope in the upper part of the posterior end. From *Bairdia subdeltoidea* Jones, described by Jones (Jones, 1849) from Cretaceous of England, and by Bosquet (Bosquet 1852, p. 29, Pl. 1, figs. 15, a,b,c,d) from Tertiary of France this species differs in having less convex dorsal margin and more asymmetrical ends. In the described species approximately one half of the anterior end is evenly rounded in the lower part, and in the posterior end only the lower part has even roundness.

Geographical distribution and geological age.—Kutch, 2½ miles west of Nareda and west of Gohela; Eocene, (?) Oligocene.

Material.—Collection contains a few shells in good preservation, belonging to adult forms. Larvae are not found.

Family *Cypridae* Baird, 1845

Genus *Paracypris* Sars, 1865

*Paracypris contermia** Lubimova and Mohan n.sp.
(Pl.II, fig. 2)

Holotype.—No. I- 4 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, Khawda; Callovian.

Original.—No. I- 14 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, Khawda; Callovian.

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* adjacent

Description.—Shell elongate, low, rounded anteriorly and tapering into an acute angle posteriorly. Maximum thickness in the middle part, gradually reducing towards the ends and margins. Left valve larger than right, overlaps it all around except anterior end, where both valves are equal. Anterior end high and gradually rounded. Posterior end low, elongate and tapering. Dorsal margin slightly convex, inclined towards posterior end, gradually connected with anterior end and forms a rounded acute angle with posterior end. Ventral margin slightly concave in the middle part. Surface of the valves smooth.

Size in mm.

Dimensions	Holotype No. I-4	Original No. I-14	Larva
Length	0.68	0.71	0.56
Height of anterior end	0.28	0.29	0.22
Height of posterior end	0.22	0.24	0.18
Thickness	0.22	0.23	0.14

Comparison.—*Paracypris contermia* Lubimova and Mohan n.sp. is very close to *Paracypris prima* Mandelstam, described by M. I. Mandelstam and G. F. Schneider (Mandelstam and Schneider, 1951, "Determination of fossil Ostracoda in the oil bearing regions of USSR", p. 38, tab. XI, figs. 1 a,b) from Upper Eocene, Dnepropetrovsk district, Nikopol region, but differs from it in having more convex and evenly curved dorsal margin, more gradual connection with the posterior end and in not having a slope on the right valve, where dorsal margin and anterior end merge. Another very close species is *Paracypris aschhabadensis* Mandelstam, described by M. I. Mandelstam and G. F. Schneider (Mandelstam and Schneider, 1951, "Determination of fossil Ostracoda in Oil bearing regions of USSR", p. 39, tab. XI, figs. 2 a,b) from Paleocene (Suzacian stage) of Middle Asia, USSR. *Paracypris contermia* Lubimova and Mohan n.sp. differs from it in having more distinct overlapping and less sloping dorsal margin, towards posterior end. The species in question is also close to *Paracypris acuta* (Cornuel), described by Cornuel (Cornuel, 1844, p. 199, tab. 1, figs. 7-8) from Neocomian of France and found by P. S. Lubimova in Upper Jurassic of Volga region, USSR (Lubimova, 1955, p. 23, tab. 1, figs. 3, a, b) but differs from it in having higher shell and different outline of dorsal margin and posterior end. Dorsal margin is more regularly convex, while in *Paracypris acuta* (Cornuel) it is strongly sloping towards posterior end.

Geographical distribution and geological age.—Kutch, Khawda; Callovian.

Material.—In the author's collection there are few shells in good preservation.

*Paracypris merdionalis** Lubimova and Mohan n.sp.
(Pl. II, fig. 3)

Holotype.—No. II- 6 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Original.—No. II- 40 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

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* Southern.

Description.—Shell elongate, irregularly oval, maximum height and maximum thickness in the middle of valves, evenly convex, gradually becoming flattened towards ends and margins. Left valve slightly larger than right and overlaps the latter all around. Overlapping is more prominent on the ventral margin. Anterior end high, evenly and gently rounded, with slight slope in the upper part, which is more distinct on the right valve. Posterior end is lower than anterior, in the upper and middle parts gently rounded and in the lower part elongate and tapering. Dorsal margin gently convex, more or less evenly connected with the ends, distinctly inclined towards the posterior end. Ventral margin slightly concave in its middle part, evenly connected with the anterior end and forms rounded acute angle with the posterior end. Surface of valves smooth.

Size in mm.

Dimensions	Holotype No. II-6	Original No. II-40	Other Specimens No. 1	No. 2	No. 3
Length	1.02	1.04	0.92	0.96	0.99
Height	0.42	0.43	0.39	0.37	0.42
Thickness of shell	0.40	—	—	—	—
Thickness of valve	—	0.20	0.17	0.17	0.20

Variation.—The species present in the author's collection, vary in degree of convexity of the dorsal margin, in height and thickness of the valves, which involves changes in outline of anterior and posterior ends. The degree of slope in the upper part of anterior end also varies. Larvae differ from adult forms in having smaller size, more convex dorsal margin (sometimes) and in not having slope at the anterior end.

Comparison.—*Paracypris meridionalis* Lubimova and Mohan n.sp. by general outline of the shell resembles *Paracypris strecca* Schmidt, described by Schmidt (Schmidt, 1948, p. 408, Pl. 63, fig. 21) from Miocene of North America, but differs from it in having larger size and dorsal margin less inclined posteriorly. The described species also resembles *Paracypris pacificus* Le Roy, described by Le Roy (Le Roy, 1943, p. 358, Pl. 61, figs. 15-18) from Pleistocene of California, but differs from it in having larger size and different outline of the dorsal margin.

Geographical distribution and geological age.—Kutch, 1 mile west of Nareda, west of Gohela, Chadopadi and Chaasra; Eocene, (?) Oligocene and Miocene.

Material.—Collection contains a large number of closed shells and valves (both right and left) mostly in good preservation. Some deformed shells and valves are also present. Among adult forms, there is a small number of larvae.

Family *Cytheridae* Baird, 1850

Genus *Krithe* Brady, Grosskey and Robertson, 1874.

*Krithe autochthona** Lubimova and Guha n.sp.
(Pl. II, fig. 4)

Holotype.—No. II- 7 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Original.—No. II-41 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Description.—Shell large, elongate (length is twice as much as height), maximum thickness in posterior part and maximum height almost in the middle part or a bit nearer to the posterior end. Left valve is slightly larger than right. Overlapping is distinct in the middle part of ventral margin and in the anterior part of dorsal margin. Anterior end high, evenly rounded, with a slight slope in the upper part. Posterior end of same height, broadly rounded in the upper and middle parts and in the lower part, steeply sloping towards ventral margin, forming an acute angle with it. Dorsal margin straight, with ends, forms rounded obtuse angle. Ventral margin concave in the middle part, gradually merges with the anterior end and forms an acute angle with the posterior end. Surface of the valves smooth.

Size in mm.

Dimensions	Holotype No. II-7	Original No. II-41	Other Specimens No. 1	No. 2
Length	0.77	0.70	0.80	0.59
Height	0.39	0.34	0.41	0.29
Thickness of shell	0.36	0.31	—	0.28
Thickness of valve	—	—	0.21	—

Variation.—This is expressed in difference in size, outline of the posterior end and degree of overlapping.

Comparison.—*Krithe autochthona* Lubimova and Guha n.sp. is very close to *Krithe producta* Brady, described by Zalanyi (Zalanyi, 1926, p. 103, Pl. XXII, fig. 4) from Upper Eocene of New Zealand, but differs in being more elongated, less high and in having more gentle antero-dorsal slope. *Krithe autochthona* Lubimova and Guha n.sp by its shape also resembles *Krithe curvidorsalis* Mandelstam and *Krithe papillosa* Mandelstam, described by M. I. Mandelstam (Mandelstam, 1950, Pl. XX, fig. 1; Pl. XX, fig. 15) from Cretaceous of Siberian Lowlands and Paleogene of Ukraine, USSR respectively, but differs from both in having straight dorsal margin.

Gographical distribution and geological age.—Kutch, 1 mile north of Chaasra, Chadopadi, Matanumaud and Babia Hill; Eocene, (?) Oligocene and Miocene.

Material.—Collection contains about one hundred shells and valves in different degree of preservation.

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* where sprang up

Genus *Leptocythere* Sars, 1928.

*Leptocythere affinis** Lubimova and Mohan n.sp.
(Pl. II, figs. 5 a,b.)

Holotype.—No. II- 8 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Original.—No. II- 42 in collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Description.—Shell small, elongate (length is twice as much as height) irregularly oval, maximum height in the anterior part and maximum thickness in the middle part of the valves, gradually reducing towards the periphery. Valves symmetrical, without visible overlapping. Anterior end high, sloping in the upper part, in the lower part evenly rounded, slightly inclined towards the ventral margin. Posterior end considerably lower than anterior, symmetrical and evenly rounded. Dorsal margin straight, intensely inclined towards the posterior end with which it is connected evenly.With the anterior end it forms rounded obtuse angle. Ventral margin intensely concaved in the middle part, evenly connected with the ends, more gently with the posterior end. Valves are covered by inconspicuous reticules with low and thick faces. The shape of reticules is rather variable, mostly irregularly oval. Regularity in disposition of reticules is not observed.

Size in mm.

Dimensions	Holotype No. II-8	Original No. II-42
Length	0.42	0.42
Height of anterior end	0.25	0.25
Height of posterior end	0.18	0.18
Thickness	0.17	0.17

Comparison.—By the general outline of the shell and the presence of reticulate sculpture, the species in question may be compared with *Leptocythere picturata* Livental, described by A. V. Suzin (Suzin, 1956, p. 93, tab. III, figs. 3, 7) from Pliocene (Akchagil stage) of Caucasus (Grozni region) but differs in having a shorter shell, indistinct reticulate sculpture and rounded (but not angular) reticules and in not having tubercle at the postero-ventral part of valves. From *Leptocythere separabilis* Mandelstam, described by M. I. Mandelstam from Pliocene of Caucasus (Kolkhida low lands) (Mandelstam, Determinaton of fossil Ostracodes, 1952, p. 714, tab. IX, fig. 19) *Leptocythere affinis* Lubimova and Mohan n.sp. differs in having different (asymmetrical) outline of the posterior end and indistinct reticulate sculpture.

Geographical distribution and geological age.—Kutch, 1 mile north of Chaasra; Miocene.

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* Similar.

Material.—Collection contains a few closed shells in fair degree of preservation.

*Leptocythere chadopadiensis** Lubimova and Guha n.sp.
(Pl. II, figs. 6a, b).

Holotype.—No. II-9 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, north east of Chadopadi; Miocene.

Original.—No. II-43 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, north east of Chadopadi; Miocene.

Description.—Shell with thick wall, irregularly oval. Maximum height in the anterior part of valve, elongate (length is twice as much as height), with slight transverse depression in the middle part. This depression starts from the middle part of dorsal margin and runs approximately to the middle part of the valve. Valves symmetrical, without visible overlapping. Anterior end high, symmetrical and evenly rounded. Posterior end slightly lower than anterior, and also evenly rounded. Some specimens have poorly expressed slope in the upper part of the posterior end. Dorsal margin straight, slightly inclined towards the posterior end, evenly connected with the ends. Ventral margin in its middle part has well expressed depression which is indistinct in larvae, evenly connected with ends, slightly elevated towards the posterior end and evenly merges with it. Surface of valves has tetrahedral or pentahedral irregularly rounded reticules with low and thick faces. The largest reticules are in the middle part of valve and they gradually decrease in size towards ends and margins. In some specimens reticules are elongated on the ventral side and form inconspicuous costae. Sometimes in the postero-ventral part an inconspicuous tubercle is seen.

Size in mm.

Dimensions	Holotype No. II-9	Original No. II-43	Other Specimens No. 1	Other Specimens No. 2
Length	0.70	0.61	0.59	0.57
Height of anterior end ..	0.35	0.34	0.31	0.31
Height of posterior end ..	0.32	0.29	0.28	0.28
Thickness of shell ..	0.26	0.25	0.21	0.20

Variation.—Variable features of this species are intensely developed reticules and tubercles on the surface of valves, as well as transverse median furrow. On some valves reticules are very distinct, on others they are hardly seen. Same is true for postero-ventral tubercle and transverse depression. Larvae differ from developed forms in having smaller size, poorly developed sculpture and better expressed slope in the upper part of posterior end. In larval forms ventral depression is hardly visible.

Comparison.—By general outline of the shell this species resembles *Leptocythere polimpsesta* var. *compressa* Livental described by A. V. Suzin (Suzin, 1956, p. 94, pl. III, fig. 9) from Pliocene (Aspheron stage) deposits of Caucasus, Grozny region, but it differs from the latter in having smaller size, coarser reticulate sculpture, and in not having ridge running near the margin of the valve in the postero-ventral part. From species *Cythere picturata* Livental described by M. I. Mandelstam (Mandelstam, 1952, p. 776, Pl. 15, fig. 8) from Pliocene of Middle Asia (Kasaksthan), *Leptocythere chadopadiensis* Lubimova and Guha n.sp. is very close to *Cythere* (?) *mironovi* Schneider, described by M. I. Mandelstam (Mandelstam, 1952, p. 708, tab. IX, fig. 5). Distinguishing features of the described species are the following: gently and evenly sloped posterior end and the presence of reticulate sculpture. In *Cythere* (?) *mironovi* Schneider the surface of valve is smooth, bearing apertures of poro-canals.

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* Name given after the locality "Chadopadi" in Kutch region where this species is first found.

Geographical distribution and geological age.—Kutch, in locality Chaasra and Chadopadi; Miocene.

Material.—Collection contains more than 20 closed shells of satisfactory preservation, among which there are several larvae, having smaller size and indistinct reticulate sculpture.

Genus *Clythrocytheridea* Stephenson, 1936.

*Clythrocytheridea autonoma** Lubimova and Guha n.sp.
(Pl. II, fig. 7).

Holotype.—No. II-10 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Original.—No. II-44 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Description.—Shell large, elongate, (length twice as much as its height), irregularly oval, maximum height in the anterior part and maximum thickness in the middle. Left valve slightly larger than the right. Overlapping distinct at dorsal and ventral margins. Anterior end high, symmetrically and evenly rounded (in some specimens the roundness of the upper part is more gentle). Posterior end lower than anterior, more sharply rounded in the lower part (in some specimens the upper part is sloping) very often inclined towards ventral margin. Dorsal margin straight, inclined towards the posterior end with which it forms rounded obtuse angle; with the anterior end connected gradually. Ventral margin almost straight, with slight depression in the middle part, merges gradually with the anterior end, with the posterior end connected more gently. Surfaceof the valves covered by tetragonal, pentagonal or rounded indistinct reticules more distinct at the posterior end and ventral part and disposed parallel to ends and ventral margin. At the postero-ventral part there is a small circular tubercle.

Size in mm.

Dimensions	Holotype No. II-10	Original No. II-44	Other specimens No. 1	Other specimens No. 2
Length	0.63	0.63	0.73	0.71
Height	0.34	0.33	0.35	0.34
Thickness of shell ..	—	—	0.30	0.29
Thickness of valve ..	0.16	0.15	—	—

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* Isolated.

Variation.—This finds its expression in different size of the shells, degree of convexity of dorsal margin resulting in change of outline of the posterior end, which in some forms is rounded more sharply and faces downwards. It is also expresed in the intensity of development of reticules and the tubercle in the postero-ventral part.

Comparison.—*Clythrocytheridea autonoma* Lubimova and Guha n. sp. in outline is very close to *Cytheridea mulleri truncatula* Goerlich and *Cytheridea acuminata* Bosquet. described by Goerlich (Goerlich, 1953, p. 131, Pl. 1, fig. 6 and p. 132, Pl. 2, fig. 9) from Tertiary of North Alps. From the first it differs in having straight dorsal margin, less distinct reticules situated in series parallel to the ventral margin, and by presence of tubercle in the pastero-ventral part of valve. From *Cytheridea acuminata* Bosquet the described species differs in having symmetrically rounded upper part of the anterior end, different outline of the upper part of the posterior end and by the presence of a tubercle in the postero-ventral part.

Geographical distribution and geological age.—Kutch, Chadopadi and Chaasra; Miocene

Material.—Collection contains many shells and valves of this species in different degree of preservation.

*Clythrocytheridea manifesta** Lubimova and Guha n. sp.
(Pl. II, figs. 8a, b).

Holotype.—No. II-11 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, south of Matanumaud; Miocene.

Original.—No. II-45 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, south of Matanumaud; Miocene.

Description.—Valve elongate, irregularly oval, maximum height and maximum thickness in the middle part. Anterior end high; evenly rounded, with 4-5 small spines in the lower part. Posterior end lower than anterior, in the upper and middle parts oblique, in lower part slightly elongated and sharply rounded, with 1-2 spines in the postero-ventral edge. Dorsal margin convex, inclined towards the posterior end and it is gradually connected to it. Ventral margin straight, gently connected with the anterior end; with the posterior end forms rounded acute angle. Surface of valve is covered by irregularly oval, indistinct reticules and outlets of poro-canals. Reticules in the central part are of the larger size.

Dimensions	Size in mm. Holotype No. II-11	Original No. II-45	Other specimen No. 1
Length	0.60	0.60	0.61
Height	0.35	0.34	0.34
Thickness of valve ..	0.15	0.15	0.15

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* Obvious.

Comparison.—*Clythrocytheridea manifesta* Lubimova and Guha n.sp. by its shape and outline resembles *Clythrocytheridea scorbiculata* Mandelstam and *Clythrocytheridea inna* Mandelstam, described by M. I. Mandelstam (Mandelstam, 1955, Pl. V, fig. 65, Pl. I, fig. 1) from Paleogene of Middle Asia (USSR), but differs from the first in being less curved in the upper part of the posterior end and from the second in having straight ventral margin and less convex dorsal margin.

Geographical distribution and geological age.—Kutch, south of Matnumaud; Miocene.

Material.—Collection contains only few valves in good preservation.

Genus *Cyprideis* Jones, 1855

*Cyprideis chaudhuryi** Lubimova and Guha n.sp.

(Pl. II, fig. 9).

Holotype.—No. II-12 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Original.—No. II-46 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Description.—Shell elongate, irregularly oval, sloping towards the ends from the middle part (may be slightly shifted towards the anterior end) of the dorsal margin. Valves regularly convex in the middle part, gradually becoming flattened towards the anterior end and more sharply towards the posterior end. Left valve is larger than right and overlaps the latter all around. On the dorsal and ventral margin overlapping is more prominent, whereas at the ends it is inconspicuous. Anterior end high, often with small spines, gently rounded in the middle and lower parts; in the upper part with distinct gentle slope. Posterior end lower than anterior, evenly and symmetrically rounded. Dorsal margin convex, (more intensely in the anterior part), gradually connected with the ends. Ventral margin straight, only few specimens have an inconspicuous depression in the middle part, evenly connected with the anterior and posterior ends. Surface of the valves is covered by irregularly oval angular reticules, with low and thick faces. Reticules are very infrequent and regularly cover the whole of surface. On some valves reticules are indistinct and in poor light, the surface of the valves seems smooth or rough.

Size in mm.

Dimensions	Holotype No. II-12	Original No. II-46	Other specimens No. 1	No. 2
Length	0.65	0.67	0.64	0.62
Height of anterior end ..	0.35	0.38	0.34	0.29
Height of posterior end ..	0.30	0.31	0.28	0.21
Maximum height ..	0.37	0.42	0.36	0.35
Thickness of valves ..	0.12	0.13	0.12	0.12

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* Name given after A. Chaudhury, Professor of Palaeontology, Calcutta University.

Variation.—This finds its expression in different length and height of the shell, degree of slope in the upper part of the anterior end and degree of convexity of the dorsal margin. There are more elongated and less higher valves and higher but less elongated ones, in the latter case, the dorsal margin is more steeply inclined towards the posterior end. The above mentioned difference in size may be a manifestation of sexual dimorphism. Reticulate sculpture also varies. In some specimens reticules are very distinct and regularly cover the whole of the surface of the valve, while in others they are hardly seen. Spines at the anterior end considerably vary in number, in some specimens they are absolutely absent. The studied material contains larvae of different stages of development, which differ from adult forms in having smaller size, more convex dorsal margin and indistinct reticulate sculpture.

Comparison.—The described species has some resemblance with *Cypridea torosa littoralis* (Brady), described by M. I. Mandelstam (Mandelstam, 1952, p. 658, tab. XXII, figs. 2, 3), from Pliocene of Turkmenia, but differs from it in having different shape of the shell and distinct bend in the middle part of the dorsal margin and also by the presence of reticulate sculpture. From species *Cypridea punctilata* (Brady), described by M. I. Mandelstam (Mandelstam, 1952, p. 659, tab. XXII, figs. 7, 8) from Miocene of Ukraine (USSR) this species differs in having more irregular shape of the shell, more convex dorsal margin and spines at the anterior end.

Geographical distribution and geological age.— Kutch, Chadopadi, Chaasra; Miocene.

Material.—Collection contains a large number of closed shells and valves of good preservation. Both adult forms and larvae of different stages of development are present.

Genus *Cythereis* Jones, 1849

*Cythereis spinellosa** Lubimova and Guha n.sp.
(Pl. II, fig. 10).

Holotype.—No. II-15 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, Nummulitic limestone near Babia hill; Eocene.

Original.—No. II-49 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, Nummulitic limestone near Babia hill; Eocene.

Description.—Shell with distinct eye spot, large, elongate (length is almost twice than its height), irregularly oval, with maximum height at the anterior part, slightly convex except anterior and posterior ends. Valves symmetrical, without visible overlapping. Anterior end high, evenly rounded in the lower part, sloping in the upper part. In some specimens the sloping is indistinct. Posterior end considerably lower than anterior, in outline looks like an irregularly rounded triangle; more gently rounded in the lower part. Dorsal margin straight, considerably inclined towards the posterior end, forming rounded obtuse angle which is more gentle with the anterior end. Ventral margin concave in the middle part, elevated towards the posterior end and is evenly connected with it; with the anterior end also connected evenly. Poro-canal zone narrow, developed all along the free margin, broader at the ends than at the ventral margin, with infrequent and indistinct straight poro-canals. Surface of valves covered by distinct spines, infrequently and irregularly disposed in the middle part, dorsal and ventral sides. Beside this, along the ends and ventral margin a marginal costa runs covered with small and frequent spines, which are blunt at the ventral margin and posterior end. In the middle part of some valve spines are thicker and look like tubercles, especially the central one (though in some shells it is absent). However, it is difficult to notice any regularity in their disposition.

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* Having numerous small spines.

Size in mm.

Dimensions	Holotype No. II-15	Original No. II-49	Other specimens No. 1	No. 2
Length	0.94	0.88	0.77	0.81
Height of anterior end ..	0.48	0.42	0.42	0.41
Height of posterior end ..	0.31	0.31	0.31	0.28
Thickness of shell ..	0.35	0.34	0.34	0.34

Variation.—This finds its expression in the degree of development of spines, in their disposition on the valves and the degree of slope of the anterior end in its upper part. Shells of different height are found, which may be connected with sexual dimorphism. Among adult forms many larvae are found, which apart from their smaller size have undeveloped spiny sculpture and more elongated form of the shell.

Comparison.—By the presence of distinct spiny sculpture on the surface of valves and general outline of valves, the described species resembles *Cythereis picta* Liepin, described by M. I. Mandelstam (Mandelstam, 1952, p. 400, Pl. LX, fig. 15) from Upper Cretaceous of West Siberian Low Lands (USSR), but differs from it, in having more developed spiny sculpture as well as more considerable difference in the height of anterior and posterior ends. From species *Cythereis spiniferina* Jones and Sherborn, described by Jones and Sherborn from Tertiary of England, and found by M. I. Mandelstam (Mandelstam, 1952, p. 383, tab. LVIII, fig. 7) in Middle Eocene of Kazaksthan, the described species differs in having more regular disposition of spines at the circular marginal costa, blunter spines, more developed tubercular sculpture in the middle part of valves and in not having reticules in the anterior part. From species *Cythereis mirandis* Mandelstam, described by M. I. Mandelstam (Mandelstam, 1952, p. 405, tab. LXI, fig. 9) from Lower Oligocene of Armenia (USSR), the described species differs in having coarser spiny sculpture and in not having reticules.

Geographical distribution and geological age.—Kutch, Nareda, Babia hill, Gohela and Matanumaud; Eocene and Miocene.

Material.—Collection contains closed shells and few valves in different degree of preservation. Among these forms larvae of different stages of development are present.

Cythereis arcanus * Lubimova and Guha n.sp.
(Pl. III, figs. 1a, b).

Holotype.—No. II-16 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 2½ miles west of Nareda; Eocene.

Original.—No. II-50 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 2½ miles west of Nareda; Eocene.

Description.—Shell with eye spot, thick walled, irregularly oval, posterior end inclined towards ventral margin, maximum thickness in the postero-ventral part where it slightly overhangs the ventral margin and gradualy becoming flat at the ends where the poro-canal zone is disposed. Valves almost symmetrical, without distinct overlapping. Anterior end high and rounded. Posterior end considerably lower than anterior, almost triangular in outline, with distinct slope in the upper part and gently rounded in the lower part. Dorsal margin almost straight, slightly inclined towards the posterior end. With the anterior end it forms rounded obtuse angle and with the posterior end forms a sharp slope, connected with the latter almost at right angle. Ventral margin slightly concave in its middle part and evenly merges with the anterior end, connection with the posterior end is very gentle. Poro-canal zone broad and flattened. Poro-canals are not seen because of mineralization. Surface of valves has large distinct reticules with thick smoothed faces. Reticules are mostly tetragonal. At the anterior end of valve, where poro-canal zone is disposed, they have the largest size and are elongated; in the rest of the shell they are more square-shaped. On the ventral side reticules are elongated and their long merged edges form slightly expressed costae. One of these costae at the inflated postero-ventral part ends in a small spine. A small angular costa, formed by faces of reticules is also seen at the postero-dorsal part of test.

Size in mm.

Dimensions	Holotype No. II-16	Original No. II-50	Other specimen No. 1
Length	0.49	0.56	0.53
Height of anterior end ..	0.28	0.29	0.27
Height of posterior end ..	0.27	0.22	0.20
Maximum thickness ..	0.27	0.31	0.32

Comparison.—By outline of shell this species has some resemblance with *Cythereis macropora* (Bosquet) described by M. I. Mandelstam (Mandelstam, 1952, p. 373, tab. LVII, fig. 5) from Upper Eocene of Ukraine (USSR) and *Cythereis hyalina* Sharapova described by M. I. Mandelstam (Mandelstam, 1952, p. 286,tab. LIX, fig. 6) from Lower Eocene of Western Kazaksthan (USSR). From the former it differs by the absence of large central tubercle and crescent shaped costa in the anterior part of valves, by the absence of spines on the anterior end and in having smaller tetragonal reticules and less developed poro-canal zone. From the latter species it differs in having less frequent and larger angular reticules, elongated posterior end and more distinct slope in the upper part of the posterior end.

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* Mysterious.

Geographical distribution and geological age.—Kutch, 2½ miles west of Nareda; Eocene.

Material.—Collection contains several shells in different degree of preservation.

Cythereis latebrosa[*] Lubimova and Guha n.sp.
(Pl. III, fig. 2).

Holotype.—No. II-13 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Original.—No. II-47 in the collection of Palaeongology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Description.—Shell thick walled, with well expressed eye spot, irregularly oval and flattened at poro-canal zone. Maximum height in the anterior part and maximum thickness in the last third of the valve. Valves become flattened more evenly towards the anterior end, at the posterior end there is a conspicuous slope. In the middle part of valves there is an indistinct transverse depression running from the middle part of dorsal margin up to the middle of the valve. Valves symmetrical and have contact with each other along the entire free margin. Anterior end is high, evenly rounded, slightly inclined towards ventral side. Posterior end considerably lower, with a distinct slope in its upper part and rounded in the lower part. Dorsal margin straight, inclined towards the posterior end, with the anterior end, it forms a rounded obtuse angle and with posterior a right angle. Ventral margin is concave in its middle part, rounded at the ends, more steeply at the anterior end. Poro-canal zone broad, flattened, with straight and radiating canals grouped in bunches. Surface of valve is intensely sculptured. On anterior part of valve there is a thin, low costa, running from the eye spot, along the anterior end. In the antero-ventral part of the valve this costa merges with the ventral costa running along the whole of ventral margin and ending at the posterior end. In the middle part of some valves there is a low, thin, slightly expressed costa ending in poorly developed tubercles in the posterior part of valve. In the middle part of valve, where usually tubercles of mandibular and adductor muscles are disposed, there is a small rounded tubercle. The rest of the surface of valve bears large coarse reticules with thick and low smoothed edges. The shape of reticules is rather variable: rounded, tetrahedral or pentahedral, irregularly oval etc.

Size in mm.

Dimensions	Holotype	Original	Other specimens	
	No. II-13	No. II-47	No. 1	No. 2
Length	0.56	0.56	0.56	0.56
Height of anterior end ..	0.36	0.36	0.35	0.35
Height of posterior end ..	0.31	0.25	0.25	0.28
Maximum thickness of shell	0.32	—	0.31	0.32
Maximum thickness of valve	—	0.16	—	—

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[*] Porous.

Variation.—This is expressed in the degree of development of reticules, median costa and the central tubercle on the surface of valve. On some valves these elements are well seen. Shape and disposition of reticules also vary considerably, as well as degree of development of transverse depression.

Comparison.—By general outline of shell and general sculpture this species resembles *Cythereis lassberi* Ulrich described by M. I. Mandelstam (Mandelstam, 1950, tab. LVI, fig. 1) from Paleogene (Middle Eocene) of Middle Asia (USSR), but differs from it in having a higher, shortened shell, conspicuous central tubercle, median costa running from the central tubercle to the posterior end, slightly expressed costae on ventral and dorsal sides and more irregular disposition of reticules on the surface of the valves.

Geographical distribution and geological age.—Kutch, Chassra, Chadopadi and Matanumaud; Miocene.

Material.—Collection contains several closed shells and some valves in good preservation.

*Cythereis pulcheris** Lubimova and Guha n.sp.
(Pl. II, figs. 3a, b).

Holotype.—No. II-14 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Description.—Shell large, elongate, irregularly oval, close to rounded triangle, with distinct eye spot and transverse median depression. Maximum thickness in the posterior and maximum height in the anterior parts of the shell. Valves symmetrical, without overlapping. Anterior end high and evenly rounded.. Posterior end low and by its shape almost triangular. Dorsal margin straight, steeply inclined towards the posterior end, forming obtuse angles with the ends. Ventral margin almost straight, sometime with slight depression in the anterior part and elevated towards the posterior end. Along the entire free margin there are small distinct spines (up to 35) becoming larger at the posterior end. In the central part of valves there is a distinct oval tubercle whose long axis is nearly normal to the dorsal margin. Directly after the tubercle, towards posterior end there is a deep distinct depression curved towards the posterior end. Slightly less distinct depression, curved towards the anterior end, runs in front of the tubercle. The rest of surface is covered by infrequent, small, irregularly disposed tubercles, most intensely developed in the posterior part.

Size in mm.

Dimensions	Holotype II-14
Length	0.65
Height of anterior end	0.35
Height of posterior end	0.24
Thickness	0.28

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* Fine.

Comparison.—By the shape of the shell this species has some resemblance with *Cythereis spiniferina* Jones and Sherborn, described by Jones and Sherborn (Jones and Sherborn, 1887, p. 453, fig. 2) from Tertiary of England and found by M. I. Mandelstam (Mandelstam 1952, p. 383, tab. LVIII, fig. 7) from Middle Eocene of Kazaksthan, (USSR) but differs from it in having a lower posterior end, by presence of distinct central tubercle and depressions and absence of spines on the surface of valves. From species *Cythereis mirandis* Mandelstam, described by M. I Mandelstam (Mandelstam, 1952, p. 405, tab. LXI, fig. 9) from Lower Oligocene of Armenia (USSR), this species differs in having a lower posterior end of triangular form and in not having curved costa in the posterior part, reticules and spines on the surface of the valves.

Geographical distribution and geological age.—Kutch, Chaasra and Matanumaud; Miocene.

Material.—Collection contains several closed shells in good preservation, belonging to adult forms. Larvae are not found.

Genus *Trachyleberis* Brady, 1898

*Trachyleberis tumefacentis** Lubimova and Guha n.sp.
(Pl. III, fig. 4)

Holotype.—No. II-19 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, north of Chadopadi; Miocene.

Original.—No. II-53 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, north of Chadopadi; Miocene.

Description.—Shell with distinct eye spot, thick, very large, irregularly oval in shape, with almost parallel margins. Maximum thickness in the middle part of valves gradually getting flattened towards the ends and margins. Left valve larger than right and distinctly overlaps it at the posterior and anterior ends and ventral margin. On the dorsal side valves simply adjoin, or right valve is slightly elevated above the left. Anterior end high, gently rounded (sometimes in the upper part roundness is more gentle), with small and frequent spines. In some specimens spines either are absent or developed very poorly. In adult forms the posterior end has equal size with anterior (in larval forms it is considerably lower), sloping in the upper part and gently rounded in the lower part. It also bears small and infrequent spines, which may be absent in some specimens. Sloping sometimes is rather indistinct or absent altogether. (This is very often the case with adult forms). In such cases the posterior end is evenly rounded. Dorsal margin straight, forms rounded obtuse angles with the ends. Ventral margin concave either in the middle part or nearer to the anterior end, merging evenly with the ends. Poro-canal zone broad, well developed at the anterior end, with straight canals, solitary or infrequently grouped in bunches. (In some specimens, however, poro-canal zone is very narrow). Surface of valves tubercular, with well developed marginal costa. This costa runs from the eye spot, along the anterior end and ventral margin, and terminates at the posterior end. Tubercles on the surface of valves are large, low, mostly irregularly oval, with broad base and smoothed in their upper part. On the surface of the valves they are usually disposed in three series, running from anterior to posterior ends. One series is on the dorsal side, second in the middle part and the third on the ventral side of the valve. In the posterior part of the valves there are some small, infrequent spines. In some specimens the disposition of tubercles may be irregular.

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* Inflated.

Size in mm.

Dimensions	Holotype No. II-19	Original No. II-53	Other specimens No. 1	No. 2	Larva
Length	0.98	0.91	1.05	0.91	0.70
Height of anterior end ..	0.56	0.55	0.56	0.53	0.35
Height of posterior end ..	0.51	0.46	0.56	0.52	0.32
Thickness of shell ..	—	—	—	—	0.31
Thickness of valve ..	0.28	0.26	0.31	0.32	—

Variation.—This finds its expression in the degree of development of costae and tubercles on the surface of valves and the nature of their disposition. In most valves tubercles are disposed in three series, but sometimes they may be irregular. Height of posterior and anterior ends as well as length of shells may also vary, which is possibly connected with manifestation of sexual dimorphism. Larvae differ from adult forms in having smaller size, different height of the ends and unparallel margins. Their posterior end is lower and dorsal margin is inclined towards the posterior end.

Comparison.—By the general shape of shell the described species may be compared with *Cythereis kwiatkowskajae* Mandelstam, described by M. I. Mandelstam (Mandelstam, 1952, p. 383, tab. LIX, fig. 9 a) from Maestrichtian of West Siberia (USSR), but differs from it in having considerably larger size, smaller number of costae and tubercular sculpture against reticular sculpture in *Cythereis kwiatkowskajae* Mandelstam. From species *Cythereis scabra* Munster described by M. I. Mandelstam (Mandelstam 1952, p. 359, tab. LV, fig. 7) from Paleogene of Middle Asia and *Cythereis verrucosa* Mandelstam, described by M. I. Mandelstam (Mandelstam, 1952, p. 361, tab. LV, fig. 8) from Lower Oligocene of Caucasus (USSR) the described species differs in having considerably larger size, equal height of ends and three distinct series of tubercles (Dorsal, median and ventral). From *Cythereis scabra* Munster the described species differs also in not having distinct central tubercle.

Geographical distribution and geological age.—Kutch, Chadopadi, Chaasra and Matanumaud; Miocene.

Material.—Collection contains a large number of shells and valves, belonging to males, females and larvae in good preservation.

*Trachyleberis memorans** Lubimova and Guha n.sp.
(Pl. III, fig. 5).

Holotype.—No. II- 21 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile west of Nareda; Eocene.

Original.—No. II-55 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile west of Nareda; Eocene.

Description.—Shell irregularly oval, with well developed eye spot. Maximum height in the anterior and maximum thickness in the middle part of valves; towards margins and ends gradually becomes flat, flattened at the ends where poro-canal zone is developed. Anterior end high, gently rounded, in the lower part sometimes slightly oblique. In some specimens along the whole of anterior end there are small and frequent spines, whose number may be up to 20. Posterior end is lower than anterior, evenly rounded. Dorsal margin straight, slightly inclined posteriorly, forming rounded obtuse angles with the ends. Ventral margin concave either in the middle part or closer to the anterior end, elevated towards the posterior end and merges with it gradually. Poro-canal zone broad, well developed at anterior and posterior ends and on the ventral margin, with infrequent, straight poro-canals. In the central part of valve there is a small distinct tubercle. Surface of the valves, including the tubercle, has large tetrahedral or pentahedral rounded reticules, faces of which on the ventral side and along the dorsal margin merge together forming slightly expressed ventral and dorsal costae. In the anterior part of valves there is a costa, parallel to the anterior end, to which reticules adjoin. At the anterior and posterior ends in the area of development of poro-canal zone reticules are of largest size and their long faces are disposed normal to ends.

Size in mm.

Dimensions	Holotype No. II-21	Original No. II-55	Other specimens No. 1	No. 2
Length	0.77	0.77	0.70	0.50
Height of anterior end ..	0.49	0.45	0.42	0.31
Height of posterior end ..	0.35	0.43	0.35	0.22
Maximum thickness of valve ..	0.24	0.21	0.24	0.15

Variation.—Specimens of this species, which are rather few in the collection vary mainly in the degree of development of reticulate sculpture and inclination of ventral margin towards the posterior end.

Comparison.—By the presence of coarse reticulate sculpture the described species to a certain extent resembles *Cythereis alveololata* Sharapova, described by M. I. Mandelstam (Mandelstam, 1952, p. 313, tab. LIV, fig. 7) from Paleocene of Kazaksthan (USSR), but differs from it in having less elongated shape of the shell, evenly rounded posterior end and less inclination of dorsal margin towards the posterior end. From *Cythereis uncinata* Mandelstam, described by M. I. Mandelstam (Mandelstam, 1952, p. 374, tab. LVII, fig. 6) from Upper Eocene of Ukraine (USSR), this species differs in having less elongated shell, poorly developed central tubercle, evenly rounded posterior end (without spines), less inclined dorsal and less elevated ventral margins (towards the posterior end).

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* Resembling.

Geographical distribution and geological age.—Kutch, west of Nareda; Eocene.

Material.—Collection contains several right and left valves of this species in different degree of preservation.

*Traychyleberis chaasraensis** Lubimova and Guha n.sp.
(Pl. III, figs. 6 a, b).

Holotype.—No. II-20 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Original.—No. II-45 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra dun; Kutch, 1 mile north of Chaasra; Miocene.

Description.—Shell large, irregularly oval, with maximum thickness in the posterior part, and gently sloping towards anterior. Left valve slightly overlaps right along the dorsal margin. Along the ventral margin overlapping is not distinct. Anterior end high, in the lower part broad and regularly rounded, slightly sloping in its upper part. Posterior end lower than anterior, with marked sloping in the upper part, inclined towards ventral margin. Dorsal margin arcuate, gradually merging with ends. Ventral margin depressed in the middle, gradually connected with the ends. Surface of the valves is covered with rounded reticules, with thick and low faces. In the ventral part the reticules are arranged in series. In postero-ventral part there is an indistinct spine, facing towards posterior. Poro-canal zone and eye spot are observed.

Size in mm.

Dimensions	Holotype	Original	Other specimens	
	No. II-20	No. II-54	No. 1	No. 2
Length	0.69	0.68	0.67	0.63
Height of anterior end	0.42	0.38	0.39	0.35
Height of posterior end	0.35	0.36	0.32	0.29
Thickness of shell	0.42	—	0.41	0.38
Thickness of valve	—	0.20	—	—

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* Name given after the locality "Chaasra" in Kutch region where this species was first found.

Variation.—This finds its expression in different degree of overlapping, in different height of the shells and the sculpture on the surface of the valves. Some valves have larger reticules, evenly distributed on the surface. In some valves reticules decrease in size towards the margins. The shape of reticules varies from rounded to oval, tetrahedral or pentahedral. Females differ from males in having higher and less elongated shape of the shell.

Comparison.—By the character of sculpture and outline, the described species is very similar to the *Trachyleberis limbata* (Bosquet) and *Trachyleberis ossabrugensis* (Lienenklaus) which were described by M. I. Mandelstam, 1950, p. 295, tab. XLVIII, fig. 3 and p. 293, tab. XLVIII, fig. 1) from Upper Eocene deposits of Ukraine (USSR). From first species it differs in having more convex dorsal margin, more even sloping in the upper part of the posterior end and by the presence of spine in postero-ventral part of the valves. Besides, poro-canal zone in *Trachyleberis limbata* is more developed than in the species described. *Trachyleberis ossabrugensis* (Lienenklaus) differs from the species in question in having uncorrugated posterior end and by absence of costae on the surface of the valve. Besides, the described species, has less projecting antero-ventral part.

Geographical distribution and geological age.—Kutch, Gohela, Chaasra, Chadopadi and Matanumaud; (?) Oligocene and Miocene.

Material.—The collection contains a large number of closed shells and valves in different degree of preservation. There are males, females and larvae of different stages of development.

*Trachyleberis fossularis** Lubimova and Guha n.sp.
(Pl. III, fig. 7).

Holotype.—No. II-17 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Original.—No. II-51 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Description.—Shell with distinct eye spot, large, elongated and irregularly oval. Maximum height in the anterior part and maximum thickness in the posterior part of the valve, flattened at the ends. Valves almost symmetrical with indistinct overlapping. Anterior end high, slightly sloping in the upper part and rounded evenly in the lower part, with 6-7 small spines. Posterior end lower than anterior, rounded in the upper and sloping in the lower part, with 2-3 spines. Dorsal margin straight, with ends forms rounded obtuse angles. Ventral margin with depression in the middle part or closer to the anterior end. Surface of the valves is covered by tetragonal or pentagonal reticules with thin and high faces. Reticules disposed concentrically regarding the middle part of the valve. A thin low costa runs all along the free margin of the valve.

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* Grooved.

Size in mm.

Dimensions		Holotype No. II-17	Original No. II-51	Other specimens No. 1	No. 2
Length	.. ..	0.71	0.61	0.67	0.78
Height of anterior end	..	0.38	0.36	0.36	0.40
Height of posterior end	..	0.36	0.33	0.33	0.38
Thickness of shell	..	—	0.38	0.41	—
Thickness of valve	..	0.22	—	—	0.23

Variation.—This finds its expression in different degree of development of reticules and the costa on the surface of valves. Some valves have more elongated, distinct tetragonal or pentagonal reticules, others have more rounded reticules. There are low and elongated or high and shortened shells which may be due to sexual dimorphism.

Comparison.—*Trachyleberis fossularis* Lubimova and Guha n.sp. closely resembles *Cythere cornucliana* Bosquet described by Bosquet (Bosquet, 1852, Pl. IV, fig. 10) from Tertiary of France but differs from it in having different form of the posterior end and steeper slope in the lower part of it, different distribution of reticules on the surface and by the absence of the central tubercle. *Trachyleberis fossularis* Lubimova and Guha n.sp. in shape resembles *Trachyleberis ferganensis* Mandelstam described by M. I. Mandelstam (Mandelstam, 1955, p. 322, Pl. III, fig. 34) from Paleogene of Middle Asia but differs from it in having a costa along the free margin, straight dorsal margin and by the absence of slope in the lower part of the anterior end. From species *Trachyleberis spongiosa* Liepin, described by M. I. Mandelstam (Mandelstam p. 403, Pl. LI, fig. 4) from Oligocene of Siberian Low Lands, *Trachyleberis fossularis* Lubimova and Guha n.sp. differs in having bigger size, slightly different outline of the shell and indistinct costa, all along the free margin.

Geographical distribution and geological age.—Kutch, Gohela, Chaasra, Chadopadi and Matanumaud; (?) Oligocene and Miocene.

Material.—Collection contains several shells and valves in different degree of preservation.

*Trachyleberis mutata** Lubimova and Guha n.sp.
(Pl. III, figs. 8, 9).

Holotype.—No. II-18 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Original.—No. II-52 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Description.—Shell with thick walls, irregularly oval, maximum height in the anterior part and maximum thickness in the postero-ventral part. In some specimens the postero-ventral part is inflated and overhangs the ventral margin. Left valve is larger than right and overlaps the latter. Overlapping is more prominent in anterior and posterior parts of the dorsal margin (where dorsal margin merges with ends) and in the middle part of ventral margin. Anterior end high, gently rounded in the upper part, more steeply rounded in the lower part and has small and frequent spines. Posterior end considerably lower than anterior, irregularly traingular in shape, sloping in the upper part and gently rounded in the lower part. At the junction with the ventral margin it has a distinct spine. In some shells, apart from this spine, some more spines are present. Dorsal margin straight, inclined towards posterior, gently connected with the anterior end and forms a rounded obtuse angle with the posterior end. Ventral margin concave in the middle part, more gently connected with posterior end. Poro-canal zone narrow. Surface of the valves is covered by distinct tetragonal, pentagonal and rounded reticules which in the middle part of valves and on the ventral side become elongated and form distinct longitudinal costae by their long merged faces. In the anterior part reticules are disposed parallel to the anterior and. In some valves at the place, where the postero-ventral part has maximum convexity, there is a small spine facing posteriorly.

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* With changed features.

Size in mm.

Dimensions	Holotype No. II-18	Original No. II-52	Other specimens No. 1	No. 2
Length	0.70	0.67	0.71	0.70
Height of anterior end ..	0.38	0.35	0.35	0.35
Height of posterior end ..	0.28	0.28	0.25	0.25
Thickness of shell ..	0.39	0.39	0.36	0.38

Variation.—This is expressed in different length and height of shells, degree of inclination of the dorsal margin towards the posterior end and the presence of slope in the upper part of the posterior end. Among the specimens available, there are more elongated and lower forms along with higher and shorter forms with distinct inflation at the postero-ventral part, which may be connected with sexual dimorphism (more inflated shells belong to females, more elongated and lower to males). Sculpture of valves is also developed differently. Some specimens have elongated reticules with thick faces, running along the shell and parallel to the anterior end and forming distinct costae. Other specimens have reticules with thinner faces and different disposition Larvae differ from adult forms in having smaller size and less developed reticulate sculpture.

Comparison.—The described species can be compared with species *Leguminocythereis pertusa* (Roem) described by Apustolescu (Apustolescu, 1955, p. 13, Pl. III, figs. 41-42), but differs from the latter in having larger inflation in postero-ventral part, less developed concentrical costae at the anterior end and terminal spines in the valves. In general outline of the shell and sculpture of valves, the described species also resembles *Cythereis tschokrakensis* Schneider, described by Schneider (Schneider, 1949, p. 166, tab. IV, figs. 3 a, b) from Miocene of Crimea (USSR), but differs from the latter in having lower, triangular posterior end, at which mostly only one spine is present, distinct inflation in the postero-ventral part of valves and slightly different character of reticules and their disposition. In *Cythereis tschokrakensis* Schneider reticules run from the anterior to posterior end as straight longitudinal lines and at the anterior end they are disposed irregularly. In the described species reticules disposed as longitudinal lines, curved parallel to the ventral margin. In the anterior part they are disposed concentrically, parallel to the anterior end.

Geographical distribution and geological age.—Kutch, Chaasra, Chadopadi and Matanumaud; Miocene.

Material.—Collection contains a large number of shells and valves of males, females and larvae in good degree of preservation.

Genus *Paijenborchella* Kingma, 1948

*Paijenborchella prona** Lubimova and Guha n.sp.
(Pl. IV, figs. 1 a, b).

Holotype.—No. II-22 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Lower Miocene.

Original.—No. II- 56 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Lower Miocene.

Description.—Shell with thick walls, elongate (length twice as large as height) with high anterior and elongated posterior ends. Maximum height in the anterior part and maximum thickness in the posterior. Valves symmetrical, without visible overlapping. Anterior end high, symmetrically rounded. Posterior end lower than anterior, with slope, strongly elongated and inclined towards ventral margin. Dorsal margin straight, slightly inclined posteriorly, with the anterior end has a rounded connection and with the posterior end forms obtuse angle. Ventral margin concave in the middle part and elevated towards the posterior end, with the anterior end connected gradually. Surface of valves is covered by small angular oval reticules which on the ventral side are parallel to ventral margin and whose merged faces form conspicuous costae. In the posterior end near the slope there are two low and round tubercles, a small one also found in the central part of valve. Very often in some shells the central tubercle is not distinct. On the anterior end and parallel to it a costa is present.

Size in mm.

Dimensions	Holotype No. II-22	Original No. II-56	Other specimens No. 1	No. 2	No. 3
Length	0.63	0.57	0.71	0.71	0.65
Height	0.28	0.27	0.27	0.29	0.25
Thickness of shell	0.21	0.22	0.22	—	—
Thickness of valve	—	—	—	0.14	0.10

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* Inclined.

Variation.—This finds its expression in different degree of development of reticules and tubercles on the surface of valves.

Comparison.—*Paijenborchella prona* Lubimova and Guha n.sp. resembles *Paijenborchella villosa* Mandelstam described by Mandelstam (Mandelstam, 1950, Pl. LXX, fig. 11), from Paleogene of Kazaksthan (USSR), but differs from it in having another form of the anterior end and more elongated posterior end, two tubercles near the posterior end and one tubercle in the central part of valve, and in not having spines in the upper part of the anterior end, dorsal margin and posterior end.

Geographical distribution and geological age.—Kutch, locality Chaasra, Chadopadi; Miocene.

Material.—Collection contains about few shells in different degree of preservation.

Genus *Cytheretta* Muller, 1894.

*Cytheretta secedens** Lubimova and Guha n.sp.
(Pl. IV, figs. 2 a, b).

Holotype.—No. II- 23 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra, Miocene.

Original.—No. II-57 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra, Miocene.

Description.—Shell elongate, irregularly oval, maximum height in the anterior part and maximum thickness in the posterior part. Valves almost symmetrical, without overlapping. Anterior end high, symmetrical, regularly rounded, sometimes with small infrequent spines. Posterior end slightly lower than anterior, in the upper part sloping, in the lower part evenly rounded and with a distinct spine. Dorsal margin straight, slightly sloping towards posterior, connected with the anterior end gradually and with the posterior end forms rounded obtuse angle. Ventral margin with slight depression in the middle part and elevated towards posterior with which it is connected more gently. Surface of valves is covered by fine elongated and frequent costae which become indistinct in the anterior part.

Size in mm.

Dimensions	Holotype No. II-23	Original No. II-57	Other specimen No. 1
Length	0.63	0.64	0.64
Height of anterior end ..	0.31	0.33	0.33
Height of posterior end ..	0.28	0.29	0.29
Thickness of shell ..	0.26	0.31	0.32

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* Differing.

Comparison.—*Cytheretta secedens* Lubimova and Guha n.sp. by character of sculpture resembles *Cytheretta alberti* (Schneider) described by Schneider (Schneider, 1949, p. 174, tab. II, fig. 6) from Miocene of Caucasus but differs in having different outline of ends, spines at the anterior end and lower part of the posterior end and in not having costae in the anterior part of valves. By character of sculpture *Cytheretta secedens* Lubimova and Guha n.sp. closely resembles *Cytheretta striata* Schneider, described by M. I. Mandelstam (Mandelstam, 1950, p. 432, Pl. XLIII, fig. 2) from Upper Cretaceous of Siberia but differs from it in having spines at the anterior end and lower part of posterior end, dorsal margin less sloping towards posterior and in not having slope in the upper part of the posterior end.

Geographical distribution and geological age.—Kutch, locality Chaasra, Chadopadi, Miocene.

Material.—Collection contains few shells in good preservation.

*Cytheretta trifurcata** Lubimova and Guha n.sp.
(Pl. IV, fig. 3).

Holotype.—No. II-24 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Original.—No. II-58 in the collection of Paleontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Description.—Shell with thick walls, elongate, irregularly oval. Maximum height in the anterior and maximum thickness in the posterior parts, gradually becomes thinner towards anterior. Left valve is slightly larger than the right, overlapping can be seen only in the ventral margin. Anterior end high, broadly rounded in the upper part, sharply rounded in the lower part and slightly inclined towards ventral margin. Posterior end lower than anterior and regularly rounded. Dorsal margin straight, slightly sloping towards posterior, evenly connected with the ends. Ventral margin slightly depressed in the middle part, elevated towards posterior and evenly connected with the ends. Sculpture consists of one high narrow circular rib, which runs along the margins and the other rib running from the central part of valve to the posterior end where it is connected with the circular rib. It is thicker in the central part. The rest of the surface is covered by indistinct reticules.

Size in mm.

Dimensions	Holotype No. II-24	Original No. II-58	Other specimens No. 1	No. 2
Length	0.59	0.55	0.56	0.52
Height of anterior end . .	0.31	0.31	0.32	0.28
Height of posterior end . .	0.26	0.25	0.26	0.25
Thickness of shell . .	0.17	0.18	—	0.18
Thickness of valve . .	—	—	0.10	—

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* Three furrowed.

Variation.—This finds its expression in different length of the valves, degree of overlapping and prominency of sculpture.

Comparison.—*Cytheretta trifurcata* Lubimova and Guha n.sp. closely resembles *Cytheretta edwardsi* (Roem) described by Schneider (Schneider, 1949, p. 175, tab. II, fig. 5) from Miocene of Caucasus, but differs from it in having central rib not joining circular rib at the anterior end. By shape and sculpture *Cytheretta trifurcata* Lubimova and Guha n.sp. resembles *Cythere plicatula* Reuss, described by Bosquet (Bosquet, 1852, p. 285, Pl. IV, fig. 13) from Tertiary of France, but differs, in not having spines at the ends, a small rib below the central rib in posterior part of valve and in having central rib not connected with the circular rib at the anterior end.

Geographical distribution and geological age.—Kutch, Chadopadi, Chaasra; Miocene.

Material.—Collection contains many shells and valves in different degree of preservation.

Genus *Progonocythere* Sylvester-Bradley, 1948.

*Progonocythere grumosa** Lubimova and Mohan n.sp.
(Pl. IV, fig. 4).

Holotype.—No. 1-5 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, Khawda; Callovian.

Original.—No. 1-15 in the collection of Palacontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, Khawda; Callovian.

Description.—Shell irregularly oval, evenly convex, with maximum height in the anterior part and maximum thickness in the middle part, gradually becoming flattened towards the periphery. Anterior end high, regularly and symmetrically rounded, slightly inclined towards ventral margin. Posterior end lower than anterior, in the upper part distinctly sloping, and gently rounded in the lower part. Dorsal margin straight, forming rounded obtuse angles with the ends. Ventral margin with median depression, elevated towards the posterior end and gradually connected with the anterior end. On the surface of the valves there are three distinct costae. Dorsal costa runs from the posterior to anterior end where it turns running parallel to the anterior end, reaching its middle part. Ventral costa runs similarly bending towards ventral margin. Median costa runs from posterior to anterior, conspicuously getting thicker in the middle part of the valves. In anterior part of the valve costae merge. Surface of the valves between the costae is coarsely reticulate. On the ventral side reticules become longer and their faces form indistinct supplementary costae running parallel to the ventral margin.

Size in mm.

Dimensions	Holotype No. I-5 (left valve)	Original No. I-15 (left valve)
Length	0.50	0.57
Height of anterior end	0.31	0.29
Height of posterior end	0.25	0.28
Thickness	0.24	0.14

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* Surface consisting of several thickenings.

Comparison.—By the outline of the shell, reticulate and costate sculpture, *Progonocythere grumosa* Lubimova and Mohan n.sp. is close to *Progonocythere catephracta* (Mandelstam) described by P. S. Lubimova (Lubimova, 1956, p. 548, tab. II, fig. 5) from Upper Jurassic deposits, Ukraine, (USSR), but differs from it in having less developed slope in the upper part of the posterior end, less number of well developed costae and their different distribution. In *Progonocythere catephracta* (Mandelstam), the anterior costa, running parallel to the anterior end, in the middle part is crossed by oblique median costa. From *Progonocythere caudata* (Terquem) var. *striata* Lubimova var. nov. described by P. S. Lubimova (Lubimova, 1956, p. 545, Pl. II, fig. 2) from Middle Jurassic deposits, Ukraine, (USSR), *Progonocythere grumosa* Lubimova and Mohan n.sp differs in having less number of well developed costae and their different disposition. Main feature of the species in description is the absence of transverse costae in the anterior part of the valve.

Geographical distribution and geological age.—Kutch, Khawda; Jaisalmer, west of Kuldhar; Callovian and Oxfordian.

Material.—In the author's collection there are only left valves in fair preservation.

*Progonocythere laeviscula** Lubimova and Mohan n.sp.
(Pl. IV, fig. 5).

Holotype.—No. I-6 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, Khawda; Callovian.

Original.—No. I-17 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, Khawda; Callovian.

Description.—Shell high, irregularly ovate, inflated in the ventral part, gradually becoming flattened towards the ends, with flat poro-canal zone at the anterior end. In the middle part of the valves there is a slight transverse depression, running from the middle part of dorsal margin to the tubercles of adductor muscles. Anterior end high, with distinctly sloping upper part and gently rounded lower part. Posterior end considerably lower than anterior and symmetrically rounded. Dorsal margin straight, sharply sloping towards posterior, with anterior end forms a rounded obtuse angle and evenly connected with the posterior end. Ventral margin with a depression in the middle part, distinctly elevated towards posterior and evenly connected with the ends. Poro-canal zone very distinct at the anterior end, with a few straight poro-canals, and indistinct at the posterior end. Surface of the valves smooth.

Size in mm.

Dimensions	Holotype No. I-6	Original No. I-17 (left valve)	Other specimens No. 1	No. 2
Length	0.64	0.63	0.70	0.69
Height	0.42	0.40	0.45	0.38
Thickness	0.18	0.21	0.21	0.31

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* Smooth.

Comparison.—By the outline of the shell *Progonocythere laeviscula* Lubimova and Mohan n.sp. is close to *Progonocythere blakeana* (Jones) described by Sylvester-Bradley (Sylvester-Bradley, 1948) from Middle Jurassic of England, but differs from it in having slight transverse depression, lower posterior end, more inflated valves in the ventral part and more sloping upper part of the anterior end.

Geographical distribution and geological age.—Kutch, Khawda; Jaisalmer, west of Kuldhar; Callovian and Oxfordian.

Material.—In the author's collection there are shells and valves, in fair preservation.

*Progonocythere implicata** Lubimova and Mohan n.sp.
(Pl. IV, fig. 6).

Holotype.—No. I-7 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, Khawda; Callovian.

Original.—No. I-18 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, Khawda; Callovian.

Description.—Shell high, with thick walls, irregularly ovate, more inflated in the postero-ventral part, gradually reducing towards the ends and dorsal margin and sharply towards the ventral margin. Anterior end high, evenly rounded, slightly sloping in its upper part. Posterior end considerably lower than anterior, sloping in the upper part and rounded in the lower. Dorsal margin slightly concave in its middle part, forming a rounded obtuse angle with the posterior end and evenly merges with the anterior. Ventral margin slightly concave, elevated towards the posterior end and gradually connected with it, with the anterior end the connection is sharp. Surface of the valves is covered by coarse, tetragonal, pentagonal and rounded reticules with thick and high faces. Reticules are disposed concentrically with regards to the centre of valves. At both the ends and ventral side, reticules become elongate and their faces merge, forming costae, which are especially distinct in postero-dorsal and antero-dorsal parts of the valves. In the central part of the valves, they are of bigger size and disposed irregularly.

Size in mm.

Dimensions	Holotype No. I-7 (Left valve)	Original No. I-18	Other specimens No. 1	No. 2
Length	0.62	0.56	0.61	0.50
Height of anterior end	0.35	0.32	0.33	0.33
Height of posterior end	0.30	0.24	0.29	0.22
Thickness of valve	0.16	0.16	0.15	—
Thickness of shell	—	—	—	0.29

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* Interwoven.

Geographical distribution and geological age.—Kutch, Khawda, Callovian; Jaisalmer, west of Kuldhar, Oxfordian.

Material.—In the author's collection, there are a few shells and valves in fair preservation.

*Progonocythere prolata** Lubimova and Mohan n.sp.
(Pl. IV, fig. 7).

Holotype.—No. I-8 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, Khawda; Callovian.

Original.—No. I-20 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, Khawda; Callovian.

Description.—Shell elongate, irregularly oval, slightly inflated at the ventral part, with maximum height in the anterior part and maximum thickness in the middle part, gradually reducing towards ends and dorsal margin. Anterior end high, with the upper part sloping and lower part evenly rounded. Posterior end considerably lower than anterior, traingular with sloping in the upper and lower parts. Dorsal margin straight, slightly inclined towards posterior, forming rounded obtuse angles with ends. Ventral margin concave in the middle part, elevated towards the posterior end with which it is connected more gradually than with anterior. Poro-canal zone broad, distinct, with well developed straight and rare poro-canals, more distinct at the anterior end and indistinct at the posterior end and ventral margin. Surface of valves with three low, smooth, longitudinal costae (dorsal, median and ventral) running from anterior to posterior end, more distinct in the middle part of the valves and gradually reducing towards ends. Dorsal and median costae are connected by an oblique transverse costa in the antero-dorsal part of the valves. The rest of the surface is covered by indistinct rounded reticules and outlets of poro-canals.

Size in mm.

Dimensions	Holotype No. I-8 (Right valve)	Original No. I-20	Other specimens No. 1	Other specimens No. 2
Length	0.56	0.53	0.57	0.53
Height of anterior end ..	0.32	0.32	0.32	0.32
Height of posterior end ..	0.22	0.21	0.22	0.22
Thickness of valve ..	0.14	—	0.14	0.14
Thickness of shell ..	—	0.28	—	—

Comparison.—By the character of its costate-reticular sculpture *Progonocythere prolata* Lubimova and Mohan n.sp. is similar to *Progonocythere memorabolis* Lubimova, described by P. S. Lubimova (Lubimova, 1956, p. 55, tab. II, figs. 8a, b) from Kimmeridgian of

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* Elongated.

Ukraine (USSR), but differs from it in having a lower posterior end of triangular shape and dorsal margin slightly inclined towards the posterior end, distinct connection of costae in the anterior part of valves and in not having central tubercle. From another species *Protocythere* (?) *infossa* Lubimova, described by M. I. Mandelstam (Mandelstam, 1952, tab. LXXV, fig. 9) from Callovian deposits of Volga region (USSR), the species in question differs in having poorly developed longitudinal costae and reticules on the surface of the valves.

Geographical distribution and geological age.—Kutch, Khawda, Callovian; Jaisalmer, west of Kuldhar, Oxfordian.

Material.—In the author's collection, there are a few shells and valves in fair preservation.

Genus *Paracytheridea* Muller, 1894.

*Paracytheridea perspicua** Lubimova and Guha n.sp.
(Pl. IV, figs. 8a, b).

Holotype.—No. II- 25 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Original.—No. II-59 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Description.—Shell rather large, elongate, irregularly oval in shape, with well developed keel on the ventral side. The keel runs from the anterior end, strongly hangs down against the ventral margin and is sharply elevated towards posterior. At the posterior part it ends in a pointed spine and is steeply truncated above the ventral side. In the middle part of the valve there is a transverse depression with gentle slopes which begins approximately in the middle of the dorsal margin and runs up to the middle of the valves. In some specimens of this species this depression runs across the whole of valve (up to the elevated keel) being curved towards posterior and as if dividing the shell into two parts: anterior and posterior. Anterior end high, evenly and symmetrically rounded. Posterior end is considerably lower than anterior (approximately half), flattened, triangular in shape, with an inconspicuous spine in its lower part. Dorsal margin straight, with anterior and posterior ends forms obtuse angles. Ventral margin slightly concave in the anterior part or nearer to the middle, strongly elevated towards the posterior end with which it forms a straight line, and rounded in the place of connection with the anterior end. Poro-canal zone narrow. Poro-canals indistinct. Along the elevated edge of the keel a thin and low costa runs, which in some specimens is rather inconspicuous. At the antero-ventral side of the valve, above the ventral keel, there is an irregularly oval tubercle. Surface of valves sculptured and covered by large angular oval reticules, whose merged faces at the ventral side form thin costae running parallel to the ventral margin. Sometimes at the posterior part of valve there are series of tubercles running from the antero-ventral tubercle to the postero-dorsal part of the valve and also forming thin, distinct costae by their merged faces. In some specimens reticulate and costate sculpture is seen indistinctly because of poor preservation of valves.

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* Apparent.

Size in mm.

Dimensions	Holotype No. II-25	Original No. II-59	Other specimens No. 1	Other specimens No. 2
Length	0.67	0.64	0.66	0.66
Height of anterior end ..	0.32	0.32	0.32	0.32
Height of posterior end ..	0.20	0.18	0.18	0.18
Maximum thickness of valve ..	0.35	0.34	0.31	0.31

Variation.—This finds its expression in the different degree of development of reticules and the antero-ventral tubercle on the surface of valves. The degree of elevation of ventral margin towards posterior also slightly varies.

Comparison.—By the general shape of valves and presence of well developed keel on the ventral side this species resembles *Paracytheridea reussi* Schneider, described by G. F. Schneider (Schneider, 1949, p. 137, tab. IV, figs. 2a, b) from Miocene of Caucasus, but differs from the latter in having larger size of valves and only one distinct slope formed by the ventral keel in the postero-ventral part of valves. In *Paracytheridea reussi* Schneider behind this slope there is a triangular projection with rounded edges, due to which posterior part of shell has a step-like character. The way of disposition of reticules in the described species also varies. From species *Paracytheridea tuberosa* Lienenklaus, described by M. I. Mandelstam (Mandelstam, 1952, p. 241, tab. LXX, fig. 4) from Upper Oligocene of Ukraine (USSR), this species differs in having different character of reticules, which in the described species form distinct costae on the ventral side of valves and in not having hollow tubercles on surface of valves.

Geographical distribution and geological age.—Kutch, locality Chaasra, Chadopadi; Miocene.

Material.—Collection contains few valves, mostly in good preservation.

Genus *Cytherura* Sars, 1865.

*Cytherura interposita** Lubimova and Guha n.sp.
(Pl. IV, figs. 9a, b).

Holotype.—No. II-26 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

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* Intermediate.

Original.—No. II- 60 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Description.—Shell small, elongate, length is twice more than height, irregularly oval, with sharply elongated posterior end and maximum height in the middle part. Left valve slightly larger than right, with small overlapping in the posterior part of ventral margin. Anterior end high, symmetrical evenly rounded. Posterior end equal in height to anterior, triangular, sharply elongated, with distinct sloping in the upper part and sharply slanting towards ventral margin. Dorsal margin straight, connected gradually with anterior and slopes towards posterior. Ventral margin with slight depression in the middle, connected gradually with the anterior end and forms rounded obtuse angle with the posterior end. Surface of valves is covered by indistinct, very fine reticules. On ventral margin they are more distinct and aligned parallel to it. Faces of reticules merge forming very fine costae, running parallel to ventral margin.

Size in mm.

Dimensions	Holotype No. II-26	Original No. II-60	Other specimens No. 1	Other specimens No. 2
Length	0.39	0.43	0.42	0.42
Height	0.18	0.19	0.19	0.19
Thickness of shell ..	0.15	0.16	0.15	0.15

Comparison.—*Cytherura interposita* Lubimova and Guha n.sp. by shape and outline of the shell resembles *Cytherura pyrama* Schneider and *Cytherura foraminosa* Mandelstam described by M. I. Mandelstam (Mandelstam, 1950, p. 882, Pl. LXXXVI, fig. 12 and p. 878, Pl. LXIX, fig. 2) from Pliocene of Caucasus and Upper Cretaceous of Turkemenia (USSR) respectively, but differs from the first in having more distinct reticular sculpture, from the second in having slight depression in the middle part of ventral margin, fine costae in the ventral part and a steeper slope in the upper part of the posterior end. *Cytherura interposita* Lubimova and Guha n.sp. by shape of shell also resembles *Cytherura fuscata* Schneider described by M. I. Mandelstam (Mandelstam, 1950, p. 876, Pl. LXVIII, fig. 9) from Miocene of Ukraine (USSR), but differs in having reticulate sculpture, fine costae at the ventral part of valves and depression in the middle part of ventral margin.

Geographical distribution and geological age.—Kutch, Chaasra and Chadopadi; Miocene.

Material.—Collection contains few shells of this species in good preservation.

Genus *Cytheropteron* Sars, 1865.

*Cytheropteron confinis** Lubimova and Guha n.sp.
(Pl. IV, fig. 10).

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* Adjacent.

Holotype.—No. II-27 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Original.—No. II- 61 in the collection of Palaeontology laboratory, Oil and Natural Gas Commission, Dehra Dun; Kutch, 1 mile north of Chaasra; Miocene.

Description.—Shell thick, irregularly oval, intensely inflated in the postero-ventral part, gradually becoming flattened towards the margins and ends. Maximum height in the middle part. Left valve is slightly larger than right and slightly overlaps the latter. In some valves overlapping is not seen. Anterior end high and evenly rounded, with visibly sloping upper part. Posterior end low, elongate, with distinctly sloping upper part, and gently rounded lower part. Dorsal margin arch-shaped more gently inclined towards posterior, gradually connected with the ends. Ventral margin with a small depression in the anterior part, gradually connected with the elevated posterior end and steeply connected with the anterior end. Surface of the valve is covered by distinct rounded tetrahedral or pentahedral reticules with thick and high faces, concentrically disposed on the ventral side and ends. At the ventral side their merged faces form poorly expressed costae. In larval forms any regularity in disposition of reticules is not observed.

Size in mm.

Dimensions	Holotype No. II-27	Original No. II-61	Other specimens No. 1	 No. 2
Length	0.48	0.53	0.49	0.49
Maximum thickness ..	0.27	0.32	0.28	0.29
Maximum height ..	0.33	0.34	0.32	0.34

Variation.—This is expressed in the intensity of development of reticulate sculpture and convexity in the postero-ventral part of valve, and also in the degree of convexity of the dorsal margin, which involves changes in outline of the ends. Larval forms, besides their smaller size, differ in having indistinct reticulate sculpture, irregular disposition of reticules, more gentle inclination of the dorsal margin towards the posterior end, and in not having distinct slope in the upper part of the posterior end and inflation in the postero-ventral part.

Comparison.—By the presence of reticulate sculpture and outline of ends this species has some resemblance with *Eocytheropteron cristatum* Mandelstam described by M. I. Mandelstam (Mandelstam, 1952, p. 600, tab. LXXI, fig. 13) from Upper Cretaceous (Turonian stage) of Turkmenia (USSR), but differs from it in having more steeply rounded, arch-shaped dorsal margin, more definitely concentrical disposition of reticules and by the presence of distinct inflation at the postero-ventral part of valve. By general outline of the shell *Cytheropteron confinis* Lubimova and Guha n.sp. also resembles *Eocytheropteron pastillum* Mandelstam described by M. I. Mandelstam (Mandelstam, 1952, p. 605, tab. LXXIII, fig. 10) from Albian of Kasaksthan (USSR), but it differs in having less inflated dorsal part of the shell, more gradual roundness of the anterior end and finer reticulate sculpture.

Geographical distribution and geological age.—Kutch, Chaasra and Chadopadi; Miocene.

Material.—Collection contains few shells and left valves in good preservation.

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EXPLANATION OF PLATES

Plate	I,	Fig. 1.	*Cytherella obscura* Lubimova and Mohan n.sp. Callovian x 84. (a) right view of closed shell. (b) dorsal view of closed shell.
,,	,,	Fig. 2.	*Cytherella disjuncta* Lubimova and Mohan n.sp. Callovian x 73. (a) right view of closed shell. (b) dorsal view of closed shell. (c) ventral view of closed shell.
,,	,,	Fig. 3.	*Cytherella protuberantus* Lubimova and Guha n.sp. Miocene x 55. (left view of closed shell).
,,	,,	Fig. 4.	*Cytherelloidea difficila* Lubimova and Mohan n sp. Callovian x 41. (a) right view of closed shell. (b) dorsal view of closed shell.
,,	,,	Fig. 5.	*Cytherelloidea cutchensis* Lubimova and Guha n.sp. Miocene x 84. (a) right view of closed shell. (b) dorsal view of closed shell.
,,	,,	Fig. 6.	*Cytherelloidea insolensa* Lubimova and Guha n.sp. Miocene x 75. (a) right view of closed shell. (b) dorsal view of closed shell.
,,	,,	Fig. 7.	*Cytherelloidea costatruncata* Lubimova and Mohan n.sp. Miocene x 49. (right view of closed shell).
Plate	II,	Fig. 1.	*Bairdoppilata poddari* Lubimova and Mohan n.sp. Eocene x 40. (a) right view of closed shell. (b) dorsal view of closed shell.
,,	,,	Fig. 2.	*Paracypris contermia* Lubimova and Mohan n.sp Callovian x 57. (right view of closed shell).
,,	,,	Fig. 3.	*Paracypris meridionalis* Lubimova and Mohan n.sp. Miocene x 50. (right view of closed shell).
,,	,,	Fig. 4.	*Krithe autochthona* Lubimova and Guha n.sp. Miocene x 51. (right view of closed shell).
,,	,,	Fig. 5.	*Leptocythere affinis* Lubimova and Mohan n.sp. Miocene x 80. (a) left view of closed shell. (b) dorsal view of closed shell.

Plate II, Fig 6. *Leptocythere chadopadiensis* Lubimova and Guha n sp.
Miocene x 64.
(a) right view of closed shell
(b) dorsal view of closed shell

„ „ Fig 7. *Clythrocytheridea autonoma* Lubimova and Guha n.sp.
Miocene x 54. (external view of left valve).

„ „ Fig. 8 *Clythrocytheridea manifesta* Lubimova and Guha n.sp.
Miocene x 77
(a) external view of right valve
(b) dorsal view of right valve

„ „ Fig 9. *Cyprideis chaudhuryi* Lubimova and Guha n sp.
Miocene x 57. (left view of closed shell).

„ „ Fig. 10. *Cythereis spinellosa* Lubimova and Guha n.sp
Eocene x 52 (left view of closed shell).

Plate III, Fig 1. *Cythereis arcanus* Lubimova and Guha n.sp.
Eocene x 97
(a) left view of closed shell.
(b) dorsal view of closed shell.

„ „ Fig. 2. *Cythereis latebrosa* Lubimova and Guha n sp.
Miocene x 52. (left view of closed shell).

„ „ Fig. 3. *Cythereis pulcherris* Lubimova and Guha n.sp
Miocene x 86
(a) left view of closed shell
(b) dorsal view of closed shell.

„ „ Fig 4. *Trachyleberis tumefacentis* Lubimova and Guha n sp.
Miocene x 51 (right view of closed shell).

„ „ Fig. 5. *Trachyleberis memorans* Lubimova and Guha n sp.
Eocene x 52. (external view of left valve).

„ „ Fig. 6 *Trachyleberis chaasraensis* Lubimova and Guha n.sp.
Miocene x 46.
(a) right view of closed shell
(b) dorsal view of closed shell.

„ „ Fig. 7. *Trachyleberis fossularis* Lubimova and Guha n sp.
Miocene x 58. (left view of closed shell).

„ „ Fig 8 *Trachyleberis mutata* Lubimova and Guha n sp
Miocene x 54. (external view of right valve).

„ „ Fig. 9. *Trachyleberis mutata* Lubimova and Guha n.sp.
Miocene x 54. (external view of right valve).

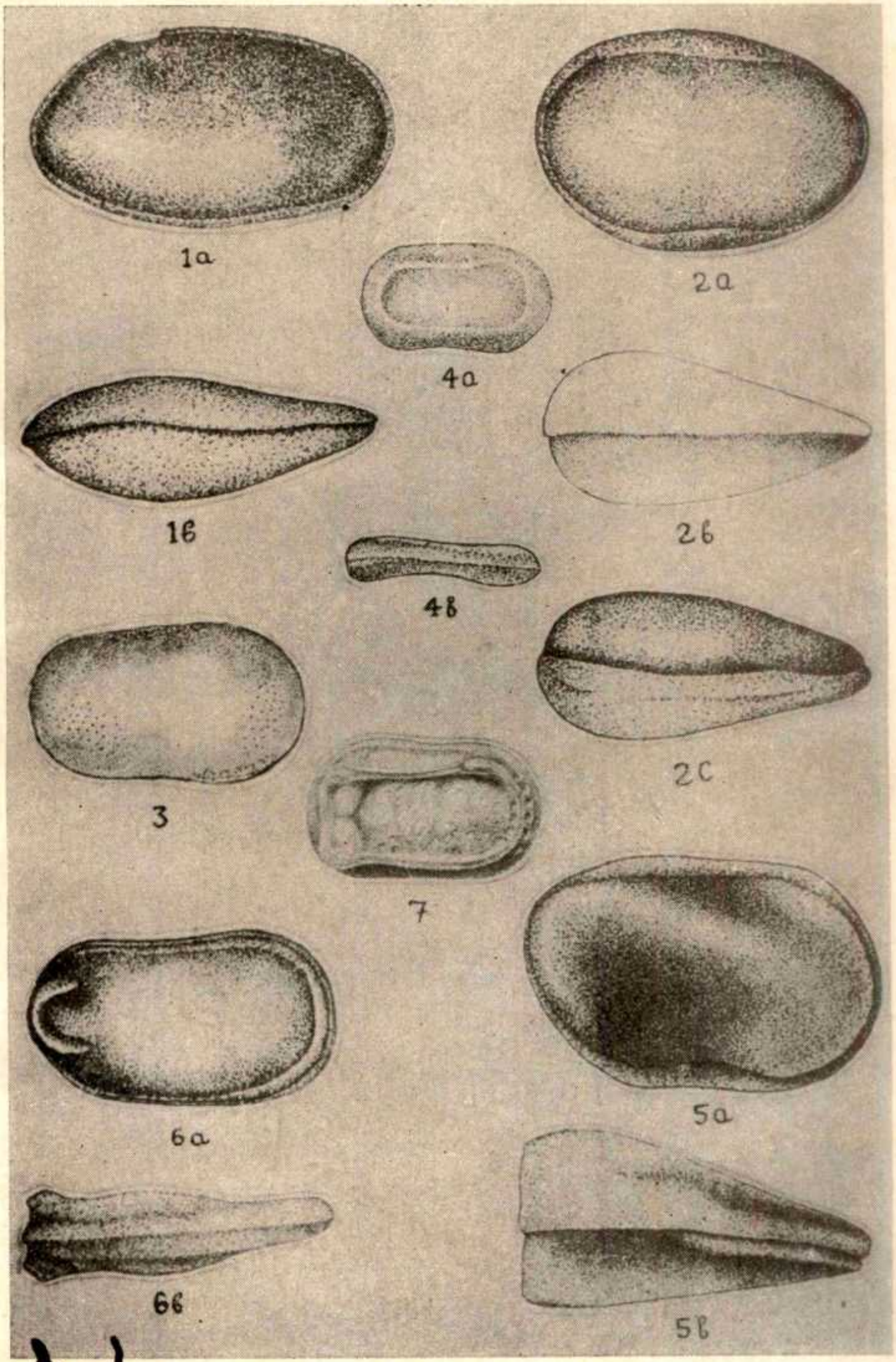
Plate IV, Fig. 1. *Paijenborchella prona* Lubimova and Guha n.sp
Miocene x 81.
(a) left view of closed shell.
(b) dorsal view of closed shell.

„ „ Fig. 2 *Cytheretta secedens* Lubimova and Guha, n sp.
Miocene x 81.
(a) left view of closed shell
(b) dorsal view of closed shell.

„ „ Fig. 3. *Cytheretta trifurcata* Lubimova and Guha n sp.
Miocene x 49. (left view of closed shell).

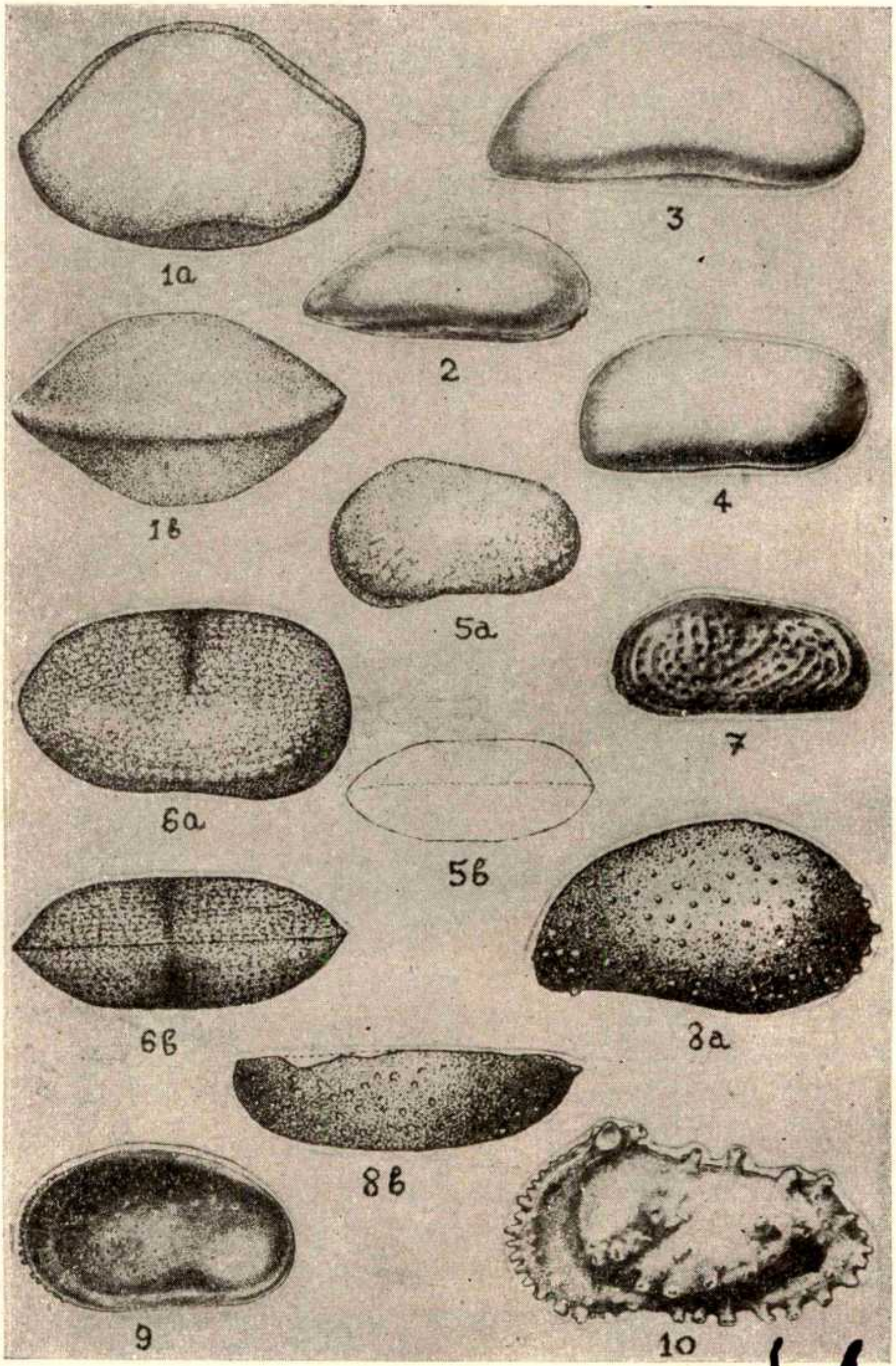
„ „ Fig. 4. *Progonocythere grumosa* Lubimova and Mohan n.sp.
Callovian x 60. (left view of closed shell).

„ „ Fig. 5. *Progonocythere laeviscula* Lubimova and Mohan n.sp.
Callovian x 52. (right view of closed shell).



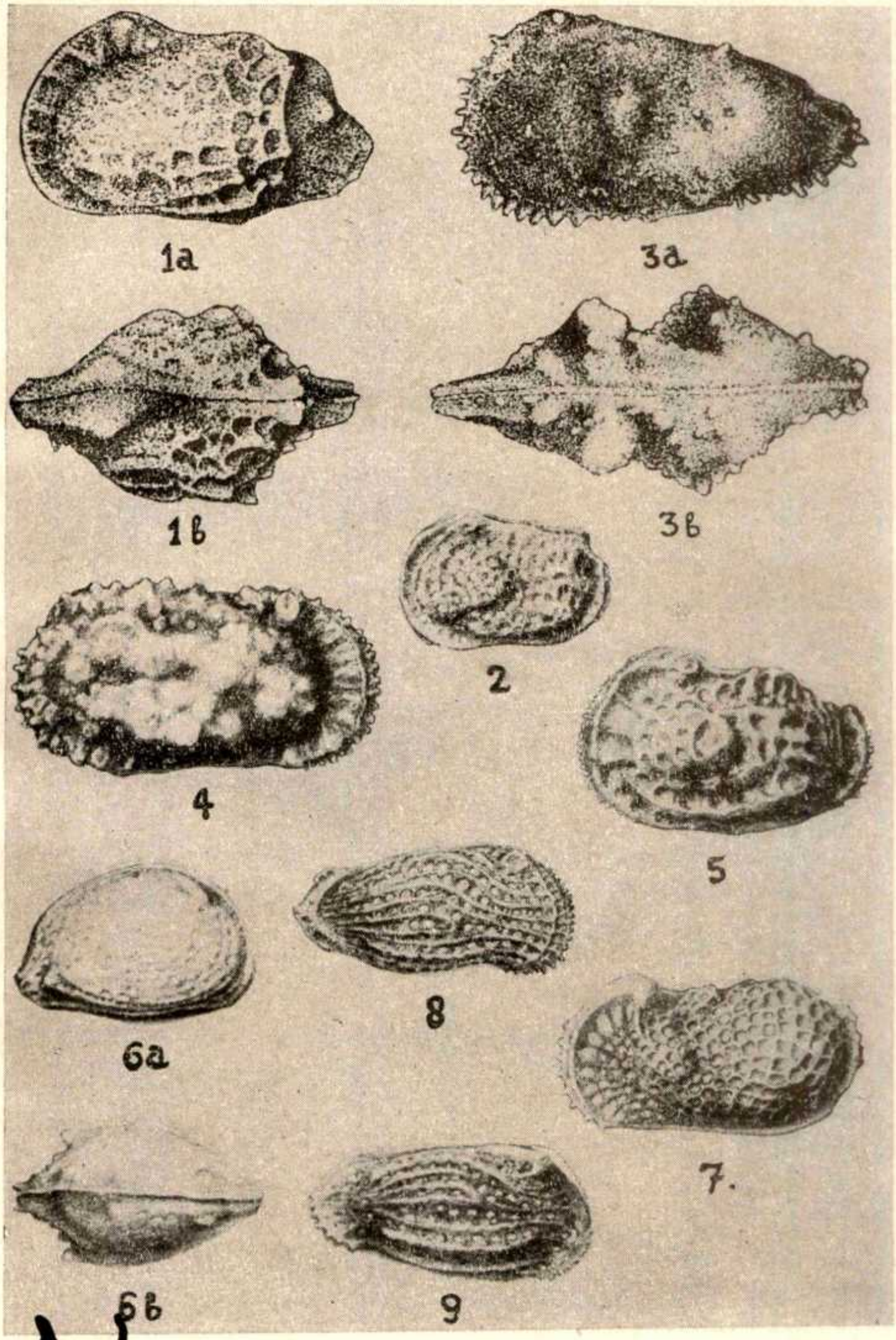
Plate—I.

Ostracoda of Jurassic and Tertiary deposits from Kutch and Rajasthan (Jaisalmer)



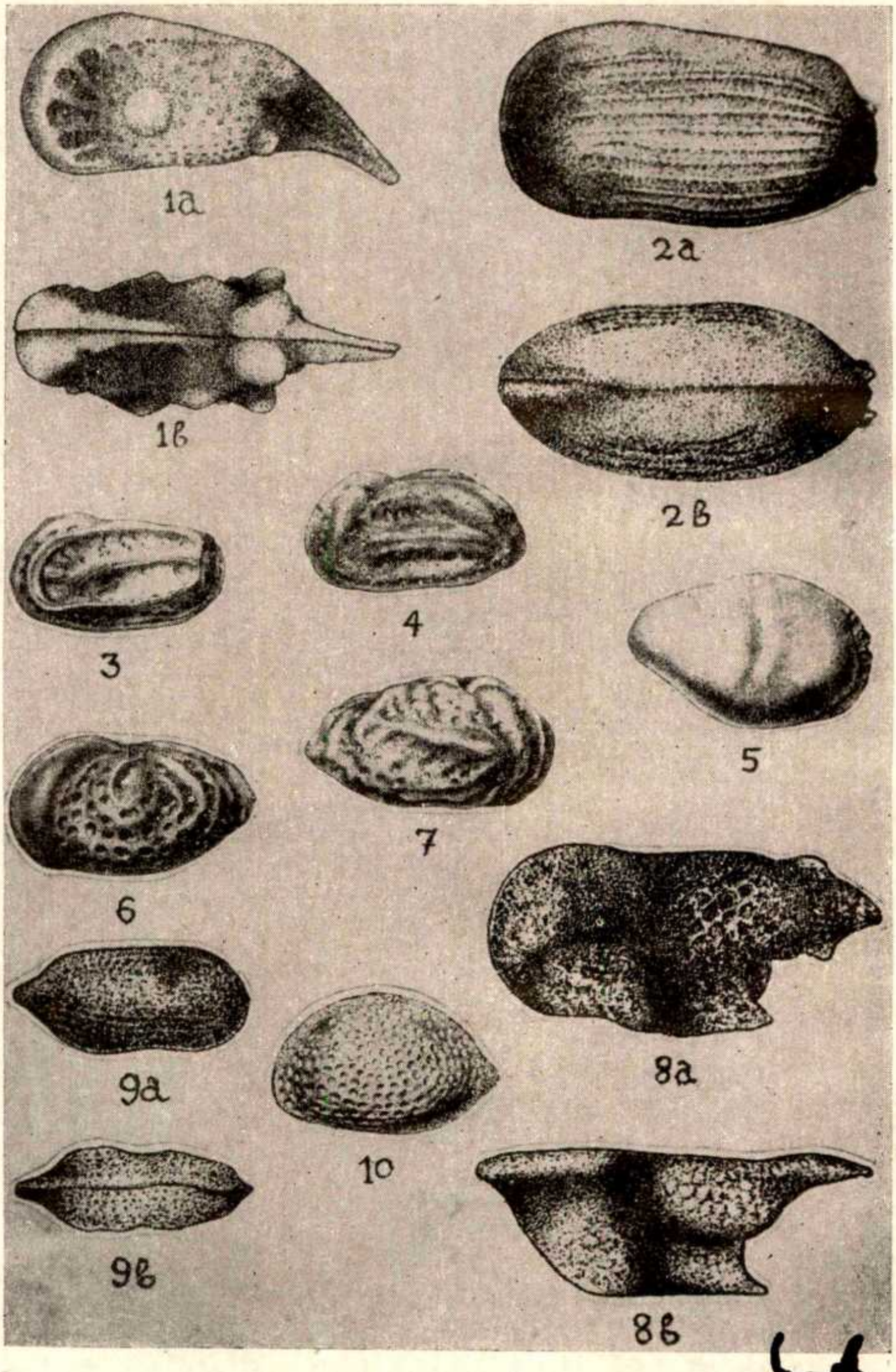
Plate—II.

Ostracoda of Jurassic and Tertiary deposits from Kutch and Rajasthan (Jaisalmer)



Plate—III.

Ostracoda of Jurassic and Tertiary deposits from Kutch and Rajasthan (Jaisalmer)



Plate—IV.

Ostracoda of Jurassic and Tertiary deposits from Kutch and Rajasthan (Jaisalmer)

Plate IV,	Fig. 6.	*Progonocythere implicata* Lubimova and Mohan n sp. Callovian x 53 (external view of left valve).
„ „	Fig. 7	*Progonocythere prolata* Lubimova and Mohan n.sp. Callovian x 68. (external view of right valve).
„ „	Fig. 8.	*Paracytheridea perspicua* Lubimova and Guha n sp. Miocene x 78. (a) external view of left valve. (b) dorsal view of left valve.
„ „	Fig 9.	*Cytherura interposita* Lubimova and Guha n.sp. Miocene x 82. (a) right view of closed shell. (b) dorsal view of closed shell.
„ „	Fig. 10.	*Cytheropteron confinis* Lubimova and Guha n.sp. Miocene x 65. (left view of closed shell).

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